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Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 28.]

LECTURE XI.

In resuming the subject of the Upper Works of Railways, the Professor said he would enter briefly into the consideration of the strongest form of rail, after explaining those points applicable alike to cast and wrought iron bars. First, a certain breadth was required for the bearing surface of the rail, for the wheel to run upon, and this breadth should be such as not to be likely to produce improper action or grooving, in the tire or tread of the wheel, and, at the same time, not to be increased so as to make the rail needlessly heavy; there must also be a sufficient depth or thickness of that bearing surface, to make it strong enough to withstand abrasion, and render the rail sufficiently stiff, and capable fully of sustaining the action of the driving-wheels of the locomotive engine. Hitherto the established breadth seemed to have been about two and a half inches on the top web, or button, and Mr. Vignoles thought, from experience, that that breadth should be considered the *minimum;* however, the strength of this bearing part of the rail, being as the breadth and square of the depth, a greater breadth than absolutely necessary to prevent the tire of the wheels being grooved, would add to the weight of the rail, without increasing the strength more than in the direct ratio of the breadth, whilst the same quantity of material, disposed in terms of the depth, increases the strength in the duplicate ratio. Considering the great increase of

weight in the locomotive engine of late years, and the continued wear and tear on the rail, from the action of the driving-wheels, and looking to the state of the iron of the upper works of those railways which have not very heavy bearing surfaces, it would seem that, while two and a half inches is a *minimum* of breadth, the chief attention is now required to the proper depth, to resist abrasion and exfoliation which takes place, especially if the iron is not perfectly well rolled. Railway bars are compounded of fagotted iron, and if the pieces are not properly welded the bearing edge is broken down, and peels off; but, supposing the iron good, and the manufacture perfect, the heavy effects of the engine must be provided against, and experience shows that an inch and a half is not too much for the depth of the top web, or bearing part of the rail, and two and a half inches being the breadth, then three and three-quarters—or, say four square inches—should constitute the sectional area of the part that is exposed in receiving the direct action of the driving-wheels; this is the section actually requisite, and the greatest additional strength being to be obtained by increasing the depth, if possible, this is the point to be attended to. It thus appears that a weight of 36 lbs. per yard is required to sustain the engine, and all beyond will belong to the mode of attaching the rail to the support below.

In treating of the wear and tear of rails, Mr. Nicholas Wood has given some curious and interesting results of experience; but the weight of the locomotive engines used is stated to have been only 10 tons, and of this the weight on the driving-wheels would probably not exceed six or seven tons. The result of a variety of experiments on the malleable iron rails of the Stockton and Darlington Railway, gave one-tenth of a pound per yard as the absolute amount of fair abrasion; some statements, however, made it much higher, being one-sixth of a pound. On the Killingworth Colliery, it was one-eighth of a pound. On the Liverpool and Manchester Railway, some years ago, three rails were taken up, carefully cleaned and weighed, relaid, and taken up again at the end of one, and again at the end of two years: the wear was found constant, and about one-tenth of a pound per yard per annum. If we were to take this to be the true wear, and suppose it to arise wholly on the upper surface of the rail, the result would be but the 84th part of an inch in depth, and it might be supposed to take 100 years to wear away a rail from mere abrasion. But later experience shows that the increased weight of engines acts very destructively on rails whose upper webs are not sufficiently strong, and of the best manufacture. We may take 10 tons as the present average weight on the driving-wheels of a locomotive engine; and, if this is to be effectually provided for, the button, or bearing part of the rail, must not be less than 40 lbs. to the yard. Now the form of the remaining part of the rail will depend upon the manner in which it is to be fastened down to the support below, either by being fixed in a chair, which is itself to be again fastened to something else, or by being screwed down, as the rails on the Great Western, Croydon, and the new part of the Greenwich Railway; or, finally, secured in the simple manner described in the last lecture. A comparatively

very small addition to the theoretical form of rail to be sustained in a chair, gives a section which has the advantage of being capable of being turned in either direction, or vertical position, and hence the top and bottom of the rails have, of late, as previously stated, been made equal and similar, connected by a neck of proportionate dimensions. With the present heavy rails, of nearly 80 lbs. to the yard, the average weight of the chairs, including the joint chairs, may be taken at 20 lbs. per yard, reducing the intervals of support to that constant distance. Thus, we have an aggregate of nearly 100 lbs. weight of iron per yard of each single rail. If, then, we could in any way get rid of the extra weight required to fasten the rail into the chair, and dispense with the chair altogether, it seemed to Mr. Vignoles to be desirable to do so, provided the object in view was equally well attained; and he contended that such would be the case with a 50 lbs. rail attached, in the mode before described, to a longitudinal bearing of timber; for the whole strength of the upper or bearing part would be retained, that being as the breadth and the square of the depth; thus, with a weight of iron just one-half, would be equally efficacious, and it only remained to compare the supports in either case. Now, as stone blocks seemed to be discarded by universal consent, the question of the supports below is narrowed to that of *transverse* or of *longitudinal* wood sleepers. Sufficient experience had been obtained to warrant the conclusion that, for the purposes of this argument, the cost of fastening and of laying the rails, ballasting, drains, &c., taken as a whole, were nearly the same for both systems, and it only remained to contrast the quantities of timber, and, always considering a locomotive line to be the one to be made, it may be stated that this cubing was about double for the longitudinal system to that in the transverse method of laying the sleepers. In short, looking at first cost only, there was a saving of 100 lbs. of iron, and an increase of two cubic feet of timber in each yard of single trackway of the former over the latter mode, so that strictly the longitudinal system was the cheapest; but to avoid minor objections, let the cost of each be taken to be the same, which was giving a decided concession in favor of the transverse system. But this was a very narrow view to take of the question, which wholly omitted the economical results from diminished wear and tear of the engines, of the railway, and of the carriages, as had been most especially exemplified on the Dublin and Kingstown Railway, where the massy granite blocks originally laid down had been all replaced by longitudinal sleepers, and though the old light 45 lb. rails and 15 lb. chairs were retained, the diminution of the annual maintenance was most remarkable, though there was not a railway in the United Kingdom were so many passengers were carried daily throughout the year.

The expense of keeping up the double way, now that the system of longitudinal timbers has been quite carried out, is less than one-third of the corresponding expense per mile per annum of maintaining the London and Birmingham Railway. Mr. Vignoles then read a variety of tabular results of the cost of the three various systems, going through all the details, and pointing out the exact measures

and quantities, and stating the actual expenditure on the upper works of various lines of railway. The result seemed, that for a double line of railway—upper works, properly laid after the bed of the road was duly prepared, including all the items under that head, which were enumerated in a former lecture, and calculating, for the present heavy and powerful locomotive engine, that no less a sum than £5000, and, in most cases, £6000, per mile was necessary, and that, in many instances, it had reached nearly £7000—the market price of iron and timber, also the quality of the latter, the greater or less facility of obtaining materials for ballast, &c., affecting the amount, and these large sums were independent of the earthwork, masonry, land, fencing, management, stations, carrying establishment, &c. Mr. Vignoles also gave a number of drawings and diagrams contrasting the three systems, and exhibiting, in a very explanatory manner, the modes of laying and fastening. He also exhibited the rail, chair and fastenings, for the transverse method, with all the recent improvements introduced by Mr. Cubitt, on the South-Eastern Railway, and as manufactured by Messrs. May, of Ipswich, and then produced the rail with the dove-tailed slot, and the mode of attachment to longitudinal half baulks of timber, repeatedly alluded to in this and the preceding lecture, observing forcibly, that, if the same effective results were obtainable by the latter simple method as by the former complicated one, it was not only to be preferred in this kingdom, but was peculiarly eligible for such countries as Russia, Poland, Germany, in general, France and America, where wood is usually in great abundance, and where iron is comparatively scarce, especially in the form required for railway bars, and, of course, the prices became in proportion. Mr. Vignoles quoted largely from the works and reports of Tredgold, Barlow, and Lecount, and stated a number of mathematical and empirical rules laid down by those authors, which, he stated, were chiefly relating to rails supported at intervals, but, though he felt it right to lay them before the class, he considered that farther experiments and investigations were requisite, and particularly in reference to the perfect combination in one support of the iron and timber in the longitudinal system, as explained and advocated by him, of which the Professor insisted, the great advantage and peculiarity was that of obtaining a perfect fastening, independent of the fibre of the wood, or the tenacity of the screws or bolts therein, and of obviating the hitherto well-founded objections to the mode of attaching rails having a continuous bearing, which had not been able to prevent a vertical play of the iron on the timber.

SECOND COURSE—LECTURE XII.—RAILWAY ESTIMATES.

This lecture had reference to the consideration of estimates, as applied to railways—that is, to ascertain lineal dimensions, superficies, and cubic contents, and affixing the proper rateable prices, to work out the monied results. The Professor said, that, probably, the most ready way to give a general idea on this subject would be to go briefly over the several heads to be considered in framing an estimate. It was assumed that proper plans and sections of the work had been

prepared in a skilful manner beforehand, Mr. Vignoles strongly insisting on the necessity and importance of having all such documents furnished on a much larger scale, and with vastly more attention to accuracy and detail, than had often hitherto been the case, particularly for Parliamentary estimates, observing, that erroneous data and calculations could not but result from a neglect of this rule: and, he stated, that, although many of the standing orders of Parliament were annoying in some respects, yet the principle on which they were framed, went to compel a compliance with forms, in doing which, greater previous investigation and accuracy of plans and sections, became absolutely indispensable.

The *quantity of land* required formed naturally the first item of an estimate. It was but seldom, indeed, that the very small economy of taking land for one line of railway only was adopted. To a given breadth, therefore, for a double line—say, from eight to ten yards—must be added the necessary allowance for fencing and ditching—say, three yards on each side—making a constant breadth of fourteen to sixteen yards of land throughout, independent of the necessary slopes in excavations and embankments; the additional quantity of these, depends, of course, on the depth of the cutting, or height of the bank, in the various places, and on the ratio of the slopes of the earthwork. Suppose, in a cutting or banking of ten feet, this ratio to be one horizontal to one perpendicular, then, such slopes of one to one require ten feet additional breadth of land on each side—together, twenty feet—viz., twice the depth or height to be added as a further breadth, beyond the constant one for the railway and fencing. In like manner, for slopes of one and a half, two, two and a half, or three to one respectively, multiply the varying depths or heights of cutting or embanking by three, four, five or six, as the case may be, for the necessarily augmented breadth of land due to the slopes, along their several extents; and thus, from the lengths measured, and the heights figured, on the section, the varying quantities of land are obtained, multiplying length by breadth, and reducing the areas to acres and parts for agricultural districts, and to square yards for land in towns and their immediate vicinities. For the prices to be assigned to these superficial quantities, the engineer must depend on the land valuer, who is also to judge of the amount of contingent damages. On an average, the actual quantity of land for a double line of railway, including the slopes of earthwork, may be taken at ten acres to the mile, but the precise areas must be ascertained in detail in the way explained. The cost of land for many of the leading lines of railway had been as much as £5000 per mile for the whole of their length. The cost of land for lines at a greater distance from the metropolis was less—still, from the numerous contingent after-charges, in respect of land, the sums were large, and had often far exceeded the original estimates.

The *fencing of the land* comes within the province of the engineer, though it is sometimes comprised in the item of land. The mode of fencing must always be regulated upon the custom and materials of the country. Drystone walls, earth mounds with furze hedges, posts

and rails, quickset hedges, and broad-side ditches or drains, are the principal kinds of fencing through agricultural lands; walls of brick or masonry, set in mortar, are generally called for through towns or building land. The several lengths of each of these are ascertained from the plans; the prices are obtained in the localities. Including farm-gates, the cost of fencing varies from 1*s.* 6*d.* to 3*s.* per yard lineal in the country. In the vicinity of towns, for stations, &c., the price will vary from 5*s.* up to 10*s.* per yard, according to circumstances, which it must be the business of the engineer to ascertain.

The third item is usually that of *Earthwork*—that is, to reduce the undulating natural surface of the ground to the railway level or gradient, by cutting through hills, and filling across valleys. Mr. Vignoles having, in the first course, entered at large into the consideration of earthwork, thought it unnecessary to say much here. The price of the earthwork depends abstractedly on the average work that an able-bodied man can perform in a day, in various soils—this it should be the study of the engineer to determine. The mere price to the workman, for getting and filling, may be taken at from 2*d.* to 5*d.* per cubic yard, for the various kinds of sands, gravels, or clays; and from 6*d.* to 2*s.* for harder materials, rocks, &c., but, in addition, various other matters are to be provided—barrows, planks, wagons, temporary railways, &c.—the present modern practice in moving large quantities of earth is vastly different to what it was in this country thirty years ago, or to what it still is on the continent, more particularly in the greater distance to which the material is carried; these several distances between the excavations and the points of depositing them, either into embankment or to spoil, must be ascertained from the longitudinal section, and a careful examination on the ground—these distances are technically called *the lead*; for distances under a quarter of a mile, the prices are higher, in proportion, than for longer distances. Taking the average description of soils, and the average distances, 1*s.* per cubic yard may be taken as a covering first estimate, upon the whole number of cubic yards of excavation or of embankment, whichever may be the larger quantity shown upon the section. The quantities of earthwork in a railway, on an average per mile throughout the whole distance, might be taken as a characteristic of its cost, so far as mere construction went, independent of carrying establishments, stations, and land, over which items the engineers seldom had control. Mr. Vignoles said it would be very interesting to have an abstract of the quantities and cost of the earthwork, distances carried, &c., on all the railways, and indeed of all other items of the works, as actually executed; they would become valuable precedents for future estimates, particularly if accompanied by explanations of the circumstances under which the operations were carried on. The great haste with which many of the railways were executed, while the late powerful excitement lasted, had added greatly to the cost, by raising the price of labor. Mr. Vignoles stated that he had already given some such abstracts of the railways that had been executed by him, or under his directions, and he was prepared to give more, and he hoped that other engineers would follow his example,

as it could not but be very satisfactory to the proprietors of the different concerns, as well as a justification to the engineers themselves, and to the directors, that they could go into the minutest detail of expenditure. The Professor then gave abstracts, in round numbers, of the quantities of earthwork on many of the principal lines of railway, as well as could be ascertained from the sections. He mentioned the North Union Railway, twenty-one miles long, with 125,000 cubic yards of earthwork per mile, at an average cost of 10¾*d.* per yard, including all extras and contingencies. The Midland Counties, 57¾ miles, with 100,000 cubic yards of earth per mile, at an average cost of 13*d.* per yard, including slips and all charges, the soils nearly the same in each, and the average lead nearly alike—viz., one mile—attributing the difference to the great haste and great demand for labor in the latter. The mean of these would be now a fair estimate.

Having estimated for the cost of obtaining the artificial bed of the railway, the next item would be the *Bridging and Masonry*—that is, to restore the previously existing communications of roads, canals, or other railways, the passage of rivers, watercourses, &c. &c., by viaducts, aqueducts, ordinary bridges, culverts, drains, &c., and often by heavy retaining and breast walls. Under this head came the bridges of brick, timber, or iron;—in very marshy countries, where the foundations are likely to be bad, and the drainings liable to be affected, timber may be resorted to, and used in the shape of piling, with cross beams to sustain the rails across the openings, avoiding thus the cost of arches, abutments, and wing walls. The ascertainment of the several superficial or cubic quantities in each of these different constructions, is a matter of simple mensuration from the working drawings. The attachment of prices to these, in all their various details, with sufficient accuracy, depends on the mature judgment and experience of the engineer; and it is by a long course of careful study and observation that the young student, in his employer's office, and on his works, can alone hope to acquire this knowledge. It was but too common, in making estimates, to fall short in this item, particularly in the number of occupation bridges, which owing to the complicated holdings, improvements, &c., had to be provided for to a vexatious extent, or bought off. The masonry is generally in proportion to the earthwork, and in many cases has happened to be of nearly the same amount of cost. The average number of bridges on a main line of railway might be taken at five for two miles. Diversions and embanked approaches of roads, gravelling or metalling the new surfaces, and the contingent operations, should be separately calculated. They are included under the head of fencing, of earthwork, or of bridging, or kept as a distinct item, according to the practice of the engineer, but they form a large sum, varying from 100*l.* to 500*l.* per mile, according to circumstances, and, in preliminary estimates, are too often omitted, or are put into that refuge for all deficient items—contingencies.

The item of *Upper-Works* in general, or *permanent way*, had been gone into so fully in the recent lectures, that it was not necessary here to do more than mention it, as forming a leading point in considering

estimates. It is usual to add 10 per cent. upon all the items of the estimate, properly belonging to the engineer. Besides these were the preliminary expenses of surveys and Act of Parliament. The management, including cost of conveying, &c., and all salaries and expenses of direction, office, engineers, solicitors, &c. &c. Then came the expenditures on the stations, engines, carriages, repairing and building shops, fittings, and all the carrying establishment necessary for passengers, also for goods and for ware houses, wharfs, and other accommodation. It was in them the heavy extra expenditure of railway capital mostly went, and which, in the early stages of the railway system, could not be properly judged of. By way of summary, Mr. Vignoles said he would give, in his next lecture, the actual cost of one or two lines of railway which had come under his direction, and which might be useful by way of reference in making out estimates on other occasions, though the construction and working of railways must be regulated on much more economical principles than had hitherto been the case, or no more of them would be undertaken.

(To be continued.)

On Bridges.

At the ordinary general meeting of the Royal Institute of British Architects, held on Monday evening, the 15th May last, Professor Hosking illustrated and explained his proposal to improve the design of arched bridges, by the introduction of a transverse arch, groined into the longitudinal arch, or series of arches; and showed the effect of this and other suggestions he has made for the improvement of bridges, in a design for remodelling Westminster Bridge.

Mr. Hosking began by stating that the closely attentive consideration of the subject of bridge designing and building, rendered necessary by his engagement with Mr. Weale, to supply a practicable treatise for the extensive work on the Theory and Practice of Bridges, now lately published, gave rise to some suggestions of improvements in design and construction, which he believes to be novel, and knows (as far as he is concerned) to be original.

His object, on that occasion, was to explain and illustrate the more important suggestions he had made, that they might not be misunderstood, and might be more extensively known than they were likely to become whilst they rested within the covers of a professional library book.

On a former occasion, in that room, he had made some remarks upon the subject of bridge building generally, and had urged that the piers of bridges were built of much greater substance in thickness, than was necessary for either safety or agreeable effect; that they might, therefore, be greatly reduced in bulk, both for economy and for their effect upon the water way, and without diminishing their efficiency. It had been objected to him, however, at that time by some of the members—with the too common fault of architects, who would sacrifice use to effect, instead of compelling the useful to be effective—that his proposal tended to destroy the due proportion in

appearance of the pier to the opening. The eye that had been accustomed to the bridges upon the Tiber, at Rome, of which the piers are rarely less than one-third the span of the larger of the two arches resting upon them respectively, would be offended by the absence of that proportion of solid to void in London and Waterloo Bridges, in which the same relation is but one-sixth; whilst the eye accustomed to the bridges upon the Thames, at London, would condemn the bridges at Staines, and the bridges of Jena and Neuilly, on the Seine, of which the piers are but one-eighth, one-ninth, and one-tenth of the span of the arches resting upon them. Nor have we yet reached the limit to which the diminution of proportion may be reduced with safety and good effect. Further to justify such further reduction, was one of the ends to be answered by the arrangement he was then to explain, which has the effect of reducing also the weight to be sustained by the piers of an arched bridge. The idea had occurred to him, and he had matured it so far as to be able to speak of it with confidence on the former occasion alluded to above, but as he was then unprepared with illustrative diagrams, he had thought it better to withhold it for the time.

The proposed improvement consists in groining a bridge arch, or in carrying a groined transverse arch through the length of a series of arches; and the advantages derivable from this plan consist in lessening the weight of the bridging constructions; in reducing the thrust upon the abutments, and, consequently confirming the stability of both arches and abutments; in diminishing the liability of the bridge constructions to vibrate under the action of pulsating or of rolling bodies; and, generally, in greatly reducing the cost of construction.

The weight is obviously lessened by the difference between the massive haunches of the main vaults, and of the requisite backing to them through the extent of the transverse arch, and the comparatively light inner transverse arch, which being of slight span, may be of stones of much less depth than the main vaults require; the thrust of the main vaults is clearly dissipated throughout so much of the width of the bridge as the inner transverse arch occupies, and so that if the latter occupy the proportion of the width that might be given to it, the abutments of the bridge may be reduced to mere wing walls; the vibrations arising from the traffic upon the bridge are checked at the groin points as at nodal points in a vibrating cord—and the groins lie directly under the carriage road where alone any action that could be felt in a heavy mass of masonry can arise;—and the cost of construction is reduced by the reduction in quantity of the materials in the piers and in the vaults—by the reduction of labor required for the softer stone available for the inner transverse arch, and by the lighter centering sufficient for the same.

He had endeavored to illustrate his suggestions by applying what he proposed upon a compartment of London Bridge, as a familiar instance, but without any idea of reflecting upon the existing condition of that magnificent work. [Here Mr. Hosking explained the

diagrams, which were merely enlargements of the plate which illustrate the same subject in the Treatise on Bridges.]

The only indication of such an arrangement as that he suggested, in any existing work with which he was acquainted, is in Perronet's Bridge of St. Maxence, where low arches are introduced over the divided parts of the piers transversely of the bridge, to take the springings of the great longitudinal arches, but these have neither the intention nor the effect of what is proposed, and are a source of weakness and expense, rather than of economy and endurance. [The diagrams which illustrated this, showed that the transverse arch was low and flat, instead of rising to the full height of the great longitudinal arches, and must, therefore, exert a great thrust upon the divided portions of the piers which abut it; and as the vaults spring upon the backs of these transverse arches, there is no relief either in thrust or weight by groining.]

He was well aware that the suggestion he had made was exposed to controversy, upon the presumption that the transverse arch may not have sufficient abutment within the length of a pier, transversely of the bridge, and as the theory of the groined arch has not been satisfactorily determined, if, indeed, it has been really investigated, he must claim to refer to experience, and assert upon example, that the inner arch, as he had drawn it in the diagram, was superfluously abutted. Under any circumstances, indeed, it can be only a question of greater or less span of the inner transverse arch, with reference to the abutments afforded to it by the springings of the outer and greater longitudinal arch to which it is groined, since there can be no question but that if the abutments are sufficient to restrain the arch, the operation may be safely carried out. In the example, the transverse inner arch occupies but half the length of the pier, leaving the minimum abutment equal to half the span of the arch, with the means of increasing it to almost any extent, by raising buttresses upon the heads of the cutwaters.

Numberless instances exist of arches of far less rise in proportion to their span, than the present example shows, abutted only by the piers on which they rest, or rather by a substance upon their haunches extending only to the thickness of their piers; the piers being far less in proportion to the span, than in the example, whilst the proportion of abutment to span should increase, as that of rise to span diminishes. Trajan's Bridge over the Tagus, at Alcantara, the Pons Palatinus, or Ponte Rotto, upon the Tiber, at Rome, the ruins of Augustus' Bridge, at Narni, are cases in point, and every cathedral chapter-house in England, in the pointed style of architecture, and every arcaded cloister, furnishes another instance to the same effect.

Another question may arise as to the sufficiency of the area of the bearing surface upon the piers at the springing of the arches, for very much less is allowed, than it has been usual to give in such cases.

Perronet calculated upon experiments, that the stone of which his Neuilly Bridge was built, is capable of sustaining twelve times the weight imposed upon it in the piers of that bridge. The area of the

bearing surface of the piers of Neuilly Bridge, is about one-tenth of the area covered by the two half arches resting upon the piers respectively. In the supposed case, the weight of the superstructure, as compared with Perronet's, is diminished by the introduction of the perforation in the arches, longitudinally of the bridge, and the stone of which London Bridge is built, being stronger than the stone used by Perronet, in a much greater degree than the difference of their specific gravities would indicate; the substance of the arches built of the stronger stone, may be relatively reduced. These circumstances operate to such an extent, that the weight of the superstructure is reduced, as compared with Perronet's work, nearly, if not quite, one-fourth; and as twelve times the sufficient strength is, besides, very much more than enough for the extremest contingencies, it is not too much to assume that the area of bearing surface of the arches at the springings, or on the piers, may be taken at one-fifteenth the area covered by the two half-arches. In justification of this assumption, it may be added that, without the same reason for it, but with flatter arches, certainly, than at Neuilly, Perronet made the area of the bearing surface upon the piers at the springings of the arches in the Bridge of St. Maxence, and with the same stone of Saillancourt, less than one-seventeenth the area in horizontal section of the space, covered by two half arches.

But the granite used in London Bridge, is of considerably more than twice the strength of the Saillancourt freestone in the bridges of Neuilly and St. Maxence, and upon which Perronet's experiments were made; and, therefore, the area of the bearing surface of the arches at the springings, may be one-thirtieth the area in horizontal section of the space covered by the two half arches resting upon any pier.

This is the proportion allowed in the case supposed, and the area of bearing face is upon the calculations regarding Neuilly Bridge, and having reference to the different powers of resistance of the two kinds of stone, more than enough for ten times the load it would be called upon to bear. Having reference, however, to other instances of the powers of stone to resist crushing pressure in the central pillars of some of the cathedral chapter-houses, it may be safely concluded that experiments upon small pieces of stone give results much within the strength of the material in the block; so that having counteracted the tendency of the traffic upon a bridge, to induce vibration in the structure by the introduction of the deep transverse arch, groined to the flat longitudinal arches; it is believed that the bearing surface at the springings of the arches, and, consequently, the piers under them, might be reduced, not merely with perfect safety, but with great advantage, very much beyond what he had now endeavored to justify, in the example before the meeting.

Mr. Hosking then proceeded to explain the advantages of corbelling out the parapets on bridges, according to the method he has proposed in his Treatise on Bridges; and read some passages in explanation of them, from that work; and showed, by diagrams, the manner in which the work might be composed constructively, and, as to decora-

tion, either plainly corbelled, or enriched faces to the parapet. He then resumed his remarks, and stated that in closing his observations upon the design and arrangement of bridges, he could not avoid noticing a pressing instance of an important work, within the personal knowledge of all who live in, or have ever visited London, rendered by circumstances which have grown up around it, altogether unfit, both in its design and arrangement, for the position it occupies. In September last, he wrote, in the *Treatise on Bridges*, as follows:—

"It is difficult to close a *Treatise on Bridge Architecture*, without remarking the increased unfitness of the present superstructure of Westminster Bridge. The arches spring at a level very little above that of low water, where the tide rises and falls from 15 to 18 feet, so that the water-way is nearly 50 feet, or about one-sixteenth less at the height of ordinary spring tides, than at the level of low water in the river. The arches contract the way for navigation much more than it is at all necessary they should, even upon the present piers, and there is more than twice the height from the soffits of the arches to the level of the roadway, than there need be; the parapets are alike offensive, by their great height from the roadway, and by their ugliness in detail, and injurious by the drafts induced by the perforations of the balustrades; and the solid counterfort buttresses over the cutwaters, and their inclosed and cupolated heads, add needlessly to the weight upon the piers. The bridge is unfortunately near to the magnificent buildings of the Houses of Parliament, and its great height renders this proximity more injurious than it might otherwise be. In all probability some abatement will be made of the height of the bridge in the process of the works now (1842) in hand for securing the pier, and, doubtlessly, the same good sense which opened a view of the river from Blackfriars' Bridge, will open the magnificent prospect Westminster Bridge can command, by substituting parapets, which shall be truly so, for the perforated walls which now hedge in the road-way; but the arches will still continue to render the navigable water-way narrower and more inconvenient than even the multiplicity and thickness of the piers, or the condition of the work, impose. The character of the work, too, will still remain inconsistent with its position at Westminster. It ought, therefore, to be completely remodelled. As the piers are now in process of being repaired and secured, and so as to be free from any danger, founding new piers is out of the question, and the piers cannot be reduced in number without imposing additional weight on those which may be left; a condition which the original defective founding, and the badness of the original structure, forbid. The whole of the superstructure might be removed, however, and the piers being carried up from the level of the present springing to that of high water, of the substance which the cutwaters now show within that range, flat pointed arches might be sprung at that level, and the whole superstructure re-constructed in accordance with the prevailing style of the Abbey, Hall, and Palace of Westminster. The longitudinal central groining herein before proposed, might well be adopted with excellent effect, lightening the upper works, relieving the thrust of the arches, and

greatly economizing the reconstruction, as the old stone would work in well for this purpose, whilst the faces and main vaults were of new. The widening of the water-way, by the removal of the springings of the arches out of the water, would allow characteristic abutments to occupy the space now taken up by the two first arches of the series of thirteen, as well as the site of the two small land arches, without affecting the current, injuriously; and as the flat, pointed arch would give much more freedom to the navigation than the semi-circular arch affords, independently of the increased lateral space in every bay, the vertical head-way might be taken at an average of that now afforded by the central group. Moreover, the increased space at the approaches obtained by obliterating the useless land arches, would allow the accesses to the bridge from the low ground on either side to be greatly improved, and the ascent eased by dividing them to the right and left over the abutments, and so to distribute the rise over a longer space, and give the means of dividing the going and coming traffic."

These observations, continued Mr. Hosking, coincide in a very remarkable degree, with those upon the same bridge, in the report lately presented by Mr. Barry, to the Commission on the Fine Arts, in connexion with the House of Parliament. It was true that his suggestions stood alone in the particulars in which it was almost certain they would be peculiar; as it regards the introduction of the inner transverse arch groined to the main vaults; the increase of the span of the arches upon the same piers, (for he did not understand Mr. Barry's report to contemplate that) and in widening, winding and dividing the approaches for the double purpose of use and delight. It was quite clear, however, that as his remarks were written in September of last year, and—with the wood-cut illustration of the subject which appears with the text—printed in October, though not published until February of this year, he might claim some credit for having taken the same view of the subject that had already, he doubted not, presented itself to the mind of their eminent contemporary, whilst it might be held to strengthen, in some degree, the view they had both taken, that it had occurred to both Mr. Barry and himself, without communication or knowledge, indeed, of each other's doings, to support it by the same train of argument.

Civ. Eng. & Arch. Journ.

Gen. Pasley *on crossing Railways, by common roads at the same level.*

Railway Department, Board of Trade, 17th March, 1843.

My Lord—In obedience to your Lordship's orders, that I should examine the projected Peterborough branch of the London and Birmingham Railway Company, and report whether the unusually numerous level crossings of turnpike, parish, and other roads intersecting it, as well as the single line of rails proposed, will be objectionable on the ground of public safety, in the event of this branch being carried

into effect; I proceeded, on the morning of the 14th instant, to Blisworth, this being the point where it is to commence; and from thence I carefully examined the whole of the line proposed as far as Peterborough, which occupied two days, because it was necessary for me to cross the Nene continually from one side to the other by a circuitous route, sometimes along the left, and sometimes along the right bank of that river.

Mr. Bidder, the second engineer of the proposed branch, in the absence of Mr. Robert Stephenson, having lent me an ordnance map on which he had traced the whole line in red, and having also supplied me with lithographed plans and sections of the same on a very large scale, that will be submitted to Parliament, I was enabled to trace it on the ground to great advantage; and I consider the line chosen between Blisworth and Peterborough to have been extremely judicious. It will descend the valley of the Nene, occasionally crossing that stream, and never receding from it more than about a mile and a quarter, to cut off the sinuosities of the river, which flows with a moderate descent through a valley varying in width, but nearly level; so that the proposed line will have the advantage of requiring few embankments and cuttings, and of very moderate height or depth, and only one tunnel, of 688 yards in length, in crossing the high ground to the south of Stibbington. Hence the level of the proposed railway will differ so little from that of the natural ground over which it is to pass, that it may be executed at much less expense than other railways in general, provided that the Company who is to form it be allowed to use level crossings for the roads that will be intersected by their line, which are so numerous, that if the bridges over all, or most of those roads be made a *sine quâ non*, it will be a complete veto to the undertaking, because, one of those bridges might cost nearly 7,000*l.*, including not merely the principal arch itself, but the approach to it, whether consisting of earthen embankments or of brick arcades, especially in those parts where the railway may require to be raised five or six feet to guard against the inundations which occur from time to time in the valley of the river Nene.

In order to judge how far level crossings may be dangerous to the public safety, I have repeatedly passed along the Northern and Eastern Railway, from Stratford to Bishop Stortford, which may be considered as a prototype of the Blisworth and Peterborough branch, as it ascends, first, the valley of the river Lee, and then that of the river Stort, in the same manner that the latter will descend the valley of the river Nene; and, in consequence of this advantage, the Northern and Eastern Railway has been completed with very little labor of earthwork, but it abounds in level crossings, there being no less than 19 or 20 in the space of 28 miles, at all of which, except private or occupation roads, gates have been erected shutting across the road, and only opened for passengers when required, at which period they are shut across the railway. This is done by a gatekeeper living in a cottage on the spot. The trains of the Northern and Eastern Railway never slacken their speed in passing those points, unless the gates should be shut across the railway, which are sufficiently con-

spicuous by day, and rendered so by a red lamp at night, which is a signal to stop. This railway has been opened, though not to the whole of its present extent, for about two years and a half, and no accident has ever occurred at any of its numerous level crossings. The example of this line is, therefore, a sufficient proof that level crossings on a railway are perfectly safe, if steady gatekeepers be employed at all of those turnpike, or other public roads; and the management of the Birmingham Railway is so very perfect, and all the enginemen, policemen, and others in their employment, so competent and correct in the execution of their duty, that I see no danger whatever in allowing them to have as many level crossings as they please in the proposed line between Blisworth and Peterborough, which will not be more numerous in proportion, than on the Northern and Eastern Railway, for the number will be about 28 in 47 miles, of which the greater part are little frequented; whilst at the crossings of the most important public roads, it is proposed to have stations where the trains will stop; indeed, on a review of railway accidents by collisions, there have been much fewer at level crossings than on the regular lines of rails, and the worst of the former occurred when the custom of shutting gates across the railway prevailed as a general rule; the danger of which having become evident, it has since been abolished. In respect to accidents to foot passengers at level crossings, these have not occurred, nor can they ever occur, except through the extreme imprudence, recklessness, or intoxication of individuals.

Upon the whole, I feel it my duty to certify that the proposed level crossings on the Blisworth and Peterborough line are unobjectionable on the ground of public safety, provided that there is a proper gatekeeper stationed at all the crossings of turnpike, parish, or other public roads; and I can see no necessity for slackening the speed of the trains at every such crossing, except for a limited time after the first opening of the proposed branch, which is always prudent in new railways.

I before mentioned that it is proposed to lay down only one line of rails between Blisworth and Peterborough, but the intention is to make the permanent roadway wide enough to admit of a second line of rails hereafter if required. In very short lines, in which the trains may go from one end to the other, and return again without meeting or crossing each other, even if there be a considerable traffic, no chance of collision can occur; but I apprehend that the proposed Peterborough branch will be too long to be worked in this manner, unless the traffic were very small indeed, and, therefore, that the up and down trains will have to cross each other at some central station, where there must be a double line of rails for that purpose. This may be effected without the smallest risk of collision by good arrangements, for which the Directors and officers of the London and Birmingham Railway Company may be trusted, and which are so obvious, that I shall not enter into details. Indeed it appears to me that there is so little difficulty in this matter, that it might be accomplished with perfect safety to the public, even without the electric

telegraph, which, however, the Company proposes to lay down along the whole of this branch, and which will be still more satisfactory, because if any accident should occur to prevent one train from reaching the central or junction station in proper time, the circumstance may be made known at that station, to do away with all suspense; and, if such accident should entirely stop, instead of merely delaying, the train, it may be got into a siding, of which there will, no doubt, be several, and when this is made known by telegraph, the trains moving in the opposite direction may proceed without being stopped also.

After having finished my inspection of the proposed branch from Blisworth to Peterborough, I returned by way of Huntingdon, Cambridge, Chesterford, Newport, Bishop Stortford, in order to view the ground over which it is proposed that the extension of the Northern and Eastern Railway shall eventually pass: and one thing is certain, that, if this extension should ever take place, no passengers from Peterborough, or the vicinity of London, will go by the circuitous route of Blisworth; so that the branch which forms the subject of this letter, will be confined to the traffic of the valley of the Nene, along which it is to pass. I have the honor, &c.,

(Signed) C. W. Pasley, *Major-General*,
Inspector General of Railways.

The Right Hon. the Earl of Ripon, &c. &c. &c.

Railway Magazine.

Preserving Timber.

Payne's Patent for preserving timber from the ravages of the dry rot, insects, &c., is now likely to be brought into extensive operation; the process consists of impregnating timber with a solution of the sulphate of iron, and forms an insoluble chemical preservative, and by the process adopted, impregnates the timber to the very centre; this is effected by placing the timber in large iron tanks with the solutions, and then first exhausting the air, and afterwards readmitting it, and then using a force-pump, with a pressure of 200 lbs. on the square inch, to force the solution into the heart of the wood, which it does very effectively. Iron, as a preservative to timber, has long been known, and it is now, through the ingenious process adopted by Mr. Payne, likely to become very extensively adopted. The Company is now preparing the timber to be used at Claremont, for the royal stables, by command of the government.

Civ. Eng. and Arch. Jour.

Architecture.

The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds. By J. C. Loudon, F. L. S., H. S., &c.

(Continued from page 54.)

II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

Having shown the use of cemeteries, we shall next consider the mode in which the ground should be laid out or arranged, with reference to these uses.

The *situation* of cemeteries, as they are at present used, that is, interring several bodies in one grave, and placing coffins in vaults, ought always to be at a distance from human dwellings; but if only one coffin were to be placed in each grave, and that grave never again opened, but the cemetery when filled, used as a public garden, its situation might be regulated solely by convenience; and, in general, the nearer the town, the more desirable it would be, both as a burial-ground and a promenade. Cemeteries, as at present used, ought to be in an elevated and airy situation, open to the north, but with a south aspect, that the surface may be dried by the sun; rather than with a north aspect, where the surface would be moist during the winter months. If the surface be even, it will be more convenient for interments, than if it were irregular, whether by broken ground, rocks, or undulations. It should be as near the great mass of the population for which it is intended, as a due regard to their health will permit, in order to lessen the expense of carriage, and shorten the time of the performance of funerals, and of visits by the living to the tombs of their friends; it ought to be conspicuous at a distance, because, from its buildings and tombs, it will generally be an ornament to the surrounding country, and an impressive memento of our mortality; and the outer boundary ought to be regular and simple, in order that it may be short, and, consequently, less expensive than if it were circuitous.

The *soil*, for reasons which we have already noticed, ought to be dry to the depth of 20 or 30 feet, or capable of being rendered so by underground drains. It ought not to be generally rocky, at least where deep graves are to be dug. As in decomposition, a considerable quantity of moisture (sanies) is exuded, the greatest care ought to be taken not to form a cemetery over a stratum of soil which contains the water used in the neighborhood for drinking. Not to mention numerous instances in London, as noticed in the *Report on the Health of Towns*, there is a churchyard near Kirkaldy, in Fifeshire, with a perpetual spring immediately without the boundary wall, the water of which, passing through a stratum under the graves, is said to be contaminated; and the burial-ground of St. Peter's Church, Brighton,

cannot be used as such, on account of the proximity of the chalky stratum which contains the water that supplies the wells of the lower part of the town.

In situations where, from the flatness of the country or the nature of the soil, there is not an opportunity of draining to a great depth, care ought always to be taken to carry off as much as possible of the surface water by shallow underground drains placed under the roads, and under the gravel walks and green paths which separate the lines of graves. No drains can be made under those parts of the surface in which graves are to be dug, for obvious reasons. Many details of this kind, which need not be entered into, will readily occur to the practical man.

The prejudices of the living, in every country, are in favor of a gravelly, sandy, or chalky soil; and in such soils draining is not required. In strong, clayey soil, like that of most of the London cemeteries, decomposition does not take place for a very long period, the fleshy part of the bodies being changed into adipocere.

The *extent* of a cemetery must, of course, depend on the population for which it is intended; the probable increase or decrease of that population; and whether one, or more than one, interment is to be made in the same grave. The data on which to form the necessary calculations, are, that the average outside dimensions of a grave are 7 ft. by 3 ft. 6 in.; that the average dimensions of a grave, where a number of them are supposed to have grave-stones, are 8 ft. by 4 ft.; and that the average deaths in a healthy population in the country are 2 per cent., and in crowded towns and cities 3 per cent. per annum. Thus, 20 graves will be required per annum for a rural population of 1000, and 200 per annum for a population of 10,000. An acre will give 1361 graves, which will afford a supply for nearly seven years; and three acres will serve for twenty-one years. At this latter period the town will probably have increased on the side next the cemetery, when the additional ground should be taken at a greater distance, and the old ground, when fully occupied, may be sprinkled over with trees, to be eventually used as a place of recreation for the living. The calculations, however, will be considerably different, if we suppose that all the graves are to be without head-stones, and, consequently, no longer than is necessary to admit the coffins. For this purpose, the average width of the grave at one end may be 2 ft., and at the other 20 in., and the length 6 ft. Taking the greater width, this will give 12 square feet to each grave, which will give 3630 grave to an acre. These graves in the London cemeteries are dug 15 ft. in depth, and ten coffins of poor persons are deposited in them. The common charge is 25*s.* for each coffin, or at the rate of the enormous sum of 45,375*l.* per acre. In some cemeteries, as many as fifteen coffins are deposited in one grave, the depth in that case being 20 or 25 feet. We could name a cemetery in which forty-five coffins, we are assured, have been deposited in one grave.

The situation, soil, and extent being fixed on, the next consideration is the *boundary fence*, which ought to be such as to insure security from theft, and favor solemnity by excluding the bustle of every-

day life, while a view of distant scenery is admitted to produce a certain degree of cheerfulness, and dissipate absolute gloom. In an open part of the country, where there are few buildings or public roads, an iron railing may be employed as a ring-fence; but, in a populous neighborhood, a wall 10 or 12 feet high, strengthened by buttresses carried up above the coping, so as to give the wall an achitectural character, may be preferable. The buttresses may be of two kinds: ordinary ones, merely for strengthening the wall, or forming piers to panels of open iron railing; and, in the case of cemeteries not laid out in beds or panels, higher and more massive piers rising conspicuously above the others, at regular distances, to receive stones having cut in them the numbers and letters used as indexes to lines for ascertaining the situations of graves, in the manner which will be hereafter described. The numbers and letters alluded to, are at present in most cemeteries painted on the brickwork, which has a mean temporary appearance; or they are put on stones or labels of cast iron inserted in the soil, and rising only an inch or two above it, which are liable to be disturbed by the moving of the ground. Though we entirely disapprove of this mode of laying out a cemetery, yet, as it is generally practiced, we have thought it right to keep it in view. Where economy is an object, a hedge and sunk wall may be used as a boundary, and the best plant for the hedge is the common holly. There ought to be one main entrance; and, if the situation admits of it, a second entrance, for the admission of workmen, carts, &c., necessary for carrying on the executive part of the cemetery.

In *laying out the interior*, the system of roads and walks, the drainage, the situation of the chapel, or chapels, and the arrangement of the graves, and of the marks which in large cemeteries, as at present laid out, are necessary, at the angles of the squares, require to be taken simultaneously, and also separately, into consideration. There ought to be at least one main road, so as to allow of a hearse having ready access to every part of the grounds; and from this road there ought to be gravel walks into the interior of the compartments formed by the roads, walks, and the boundary wall; and, from these gravel paths, ramifications of narrow grass paths, so as to admit of examining the graves in every part of the grounds, without walking over any of them, and thus insure respect for the dead. We have already observed that all the drains that require to be made must be under these roads, walks, and paths, so as not to interfere with the graves; and the ranges of situations for graves must be determined before the roads, walks, and green alleys are fixed on, otherwise there might be a waste of ground. To be convinced of the bad effects of the neglect of surface drainage in a cemetery, it is only necessary to walk on the grass of that at Kensal Green during winter or spring.

The first point to be attended to, according to the present system, unless the cemetery should be a small one of only an acre or two, is to devise a system for *throwing the interior into imaginary squares or parallelograms*, which shall be indicated by numbers and letters on the boundary fence, and by marks inserted in the ground at their points of intersection. In cemeteries of moderate dimensions, more

particularly if the form be rectangular, the marks at the intersections of the squares may be dispensed with; these intersections being readily ascertained when it is desired to find out the precise situation of any grave, by stretching lines across the cemetery from the letters and figures on the boundary fence. For example, suppose fig. 1 to represent a cemetery of five acres, with the letters A, B, C, &c., marked at regular distances on the end walls, and figures 1, 2, 3, &c., at the same distances on the side walls; then, by stretching one line from B to B, and another from 2 to 2, &c., the intersections of the strings will give the points B 2, C 2, &c.: but supposing the surface of the cemetery to be very hilly, or that it is thickly studded with tombs or trees, then, as the lines could not be readily stretched so as to give the points B 2, C 2, &c., with perfect accuracy, a stone, or mark of cast iron, is inserted when the cemetery is first laid out, in each of the intersecting points, with the letter and figure on it, as shown in the diagram fig. 1, at B 2, C 2, D 3, &c. At every other point of intersection throughout the cemetery, there is a sunk stone, or iron, inserted, with the letter which stands at the ends of the long lines, and the figure which stands at the ends of the cross lines, as shown on a large scale in fig. 2. Thus in the diagram fig. 1, we should have the squares A 1, B 1, C 1, D 1, &c.; and A 2, B 2, C 2, &c. The use of these squares is to enable the sexton to ascertain and point out, at any future time during the existence of the cemetery, the precise spot where any interment has taken place. For example, required to see the grave of T. W. On turning to the index of the register book of names, T. W. is found to have been interred in the square B 4. Now, on turning to the map book of the cemetery, in which every imaginary square into which the cemetery is parceled out, is laid down on a large scale, the position and dimensions of the grave will be found delineated according to the scale; and then, by taking the dimensions from two of the sides of the square and applying them to the ground, the exact position of the grave is found, even though the grave mound should be obliterated. Now it must be evident that it would be exceedingly inconvenient to have the stone marks fall into positions where buildings were to be erected, or roads or walks to be laid out; and hence the propriety, as we have said above, of determining the position of the intersections of the squares, before any other part of the laying out is proceeded with. This is the more necessary in cases where the intersecting points are to be marked by trees of particular kinds, or by an obelisk, or other monumental stone. By using an obelisk or other pillar with four sides, pointing diagonally to the four squares, as at

Fig. 1.

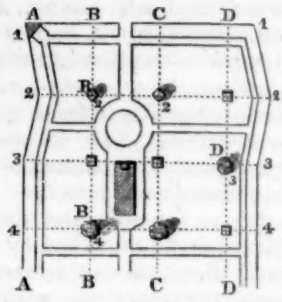
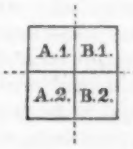


Fig. 2.



B 2, and C 2, in the diagram fig. 1, these stones would not only serve to indicate the intersections of the squares, but to record the names of those buried in each square, if the parties interested thought fit to incur the expense. It is not necessary that all the squares or parallelograms should be of the same size; on the contrary, their dimensions may be varied, so as to suit the ground, the boundary, and all the different circumstances connected with the general arrangement. In some cases the intersections of the squares might be indicated by trees, as shown at B 4, D 3, &c.

It must be confessed, however, that this system of laying out a cemetery into imaginary squares, is a very unsatisfactory one, for the following reasons:—1. It neither admits of a permanent system of surface drainage, nor of grass paths among the graves. 2. From there being no obvious principle of order or arrangement in conformity with which the graves are placed, the general aspect of the interior of the cemetery is confused and unsatisfactory; the graves and tombstones seeming to be put down at random as in common churchyards. 3. A very slight error in mapping the graves may render it difficult, if not impossible, to identify a particular grave, either to point it out to the relations of the deceased; or, when the square is nearly full, for the purpose of avoiding an old grave in digging a new one. Let any one who doubts this, examine the map books in the principal London cemeteries, and ask to see one of the graves indicated in the plan. 4. Unless a head-stone is put to the grave, or some other permanent mark, it is impossible for any person but the sexton to identify it; which circumstance can by no means be rendered satisfactory to the relations of the deceased. 5. No provision is made for paths among these graves, so that, when the squares are nearly full, there will be no mode of getting to any one grave, but by walking over a number of others; which is not only a species of desecration, but, when there are several of the graves having headstones, must be exceedingly inconvenient.

A much better system, in our opinion, is to lay out the ground in what may be called double beds with green paths between, in the manner to be described in a future paragraph, which has an orderly appearance, admits of a permanent system of surface drainage, requires no mapping, and enables the friends of the deceased to recognize the grave they wish to see, without troubling the sexton or any one else. This laying out of the ground in double beds need not be so executed as to have a formal appearance, though it should be sufficiently distinct to give what, in the language of art, is called the expression of purpose, and thus give the lawn of a cemetery a different character from that of the lawn of a pleasure-ground. The double beds may be slightly raised in the middle, so as to slope to the grass paths, and the surface of these paths, if only 3 in. below that of the beds, will be a sufficient distinction, when the whole is near the eye; while, at a short distance, the difference between the beds and the paths will scarcely be perceptible. We mention these things to anticipate objections on account of the supposed formality of this plan. Under every green path there may be a tile drain, which will render

it as dry as a gravel walk. The path will answer if only 3 ft. wide, because, in carrying a coffin along it shoulder high, that space is sufficient; but 4 ft. is preferable, as admitting of carrying a coffin by hand-spokes. Where the hand-bier, to be hereafter described, is used, a 2-feet path would be wide enough.

In making arrangements for the *situations of graves*, regard must be had to the wealth and taste of the persons who will probably use the cemetery, and the proportion of situations for sumptuous tombs and monuments adjusted accordingly. At the same time, we should mark no part of the ground as exclusively devoted to any class of society, of graves or of monuments; nor should there be any part in which a monument might not be erected. In general, we would form a broad border, say from 12 ft. to 20 ft. wide, along the main roads; a border immediately within the boundary fence, of the same width as the height of the latter; a border from 8 ft. to 12 ft. wide on each side of the gravel walks; and the interior of the compartments we would lay out in beds or zones, straight or curved, with green alleys of 3 or 4 feet between. These beds ought to be of such a width as to contain two rows of graves, with the head stones of each row placed back to back in the middle of the bed, so as to face the alleys. The necessary width for this purpose is 18 ft.; which will allow 7 ft. for the length of each grave; 1 ft. at the head of each grave, on which to erect a headstone, or other monument not exceeding 1 ft. in thickness nor the width of the grave; and 1 ft. at the end next the walk, for a foot-stone or number. This head-stone or monument, it may be observed, should in no case be built on the soil, but on two brick piers brought up from the bottom of the soil to the surface of the ground, in the manner to be hereafter described.

The directions of the *roads, walks, and green paths*, is partly a matter of necessity, and partly of design and taste. Where the surface of the ground is hilly, undulating, or otherwise irregular, winding roads become necessary; but where the surface is tolerably even, whether a uniform slope or a flat approaching to a level, the choice lies between straight lines and curvilinear ones. The direction of the roads and walks, and, consequently, the whole of the interior arrangement of the cemetery, are thus in a great measure controlled by the character of its surface. In general, straight roads and walks are greatly to be preferred in a cemetery to winding ones, not only as admitting of a more economical occupation of the ground, every grave being a rectangle, and every rectangle being a multiple or divisor of every other rectangle, but as contributing far more than curved lines to grandeur and solemnity of effect. If all the roads cannot be made straight, there ought, if possible, to be one broad and straight road from the main entrance to the chapel. A winding road from the main entrance, with the chapel concealed by trees, has too much the character of an approach-road through a park to a country residence. The roads may vary from 12 ft. to 20 ft. in width, according to the extent of the cemetery; the walks should not be narrower than 5 or 6 ft., nor the green paths than 3 or 4 ft.

The *chapel, or chapels,* ought to be placed in a central and conspicuous situation, so as, if possible, to be seen from all the prominent points of view along the roads and walks. At the main entrance there may be a lodge, or lodges, in which the sexton or superintendent of the ground may reside, and in which also there ought to be an office for the cemetery books and plans, or duplicates of them, and for receiving orders for funerals, &c. One lodge will generally be found preferable to two, because, where lodges are of such a size as to be useful, and are widely separated by spacious gates, they attract attention as separate objects, and do not group together so as to satisfy the eyes as a whole. If there are two separate lodges with intervening gates, the lodges ought not to be higher than the piers between the gates; and they ought to seem rather as massive terminations to the gates than as lodges, in short, as a part of the facade. A striking example of the bad effect of two large lodges, is afforded by the Nunhead Cemetery. The Abney Park Cemetery shows a judicious combination of two lodges with gates between; there is a very good single lodge at the west entrance to the Tower Hamlets Cemetery; and the Kensal Green and West London Cemeteries, afford examples of the lodge and gateway combined in one edifice, the gateway forming an arch through it. Where it is considered absolutely necessary to have two lodges, either to a cemetery or to the park of a country residence, they ought to be combined with the piers of the gates, as at the Abney Park Cemetery; formed into one pile of building with the gateway, as at the West London Cemetery; or one lodge ought to be much larger and higher than the other, in order to form a central mass or axis of symmetry, or, in Hogarth's language, to form the apex of the triangle.

A *yard and sheds* for the cemetery tools, implements, and other cemetery furniture, including a carpenter's shop, may also be conveniently placed near the lodge; but where the cemetery is large there ought to be two or three sheds for planks, barrows, &c., in different parts of the ground. In most cases a reserve ground for spare earth, produced from time to time as brick graves or vaults are formed, for rubbish of various kinds, and for nursing plants, to be placed over the graves when wanted for that purpose, may be requisite. On a large scale, a mason's yard with sheds is essential; unless, which is much the better mode, there should be an establishment of this kind in the immediate neighborhood, by which all the brick and stone work would be done by contract.

On the introduction of *trees and shrubs* into cemeteries, very much of their ornamental effect is dependent; but too many trees and shrubs impede the free circulation of the air, and the drying effect of the sun, and, therefore, they ought to be introduced in moderation. They ought not, as we think, to be introduced in masses in the interior of the cemetery, nor in strips or belts round its margin, unless under very particular circumstances. Every mode of introducing trees and shrubs, which is identical with that practiced in planting parks and pleasure-grounds, is to be avoided, as tending to confound the character and expression of scenes which are, or ought to be, essentially

distinct. Independently of the injury done by masses and belts in impeding the free circulation of the air, they prevent the ground on which they stand from being occupied by graves; and though there may be no immediate occasion for so occupying that ground, yet an arrangement which seems to be at variance with, or at least to have no reference to, the purpose for which the cemetery was formed is unsatisfactory. There is evidently not the same objection to single trees or single shrubs; because, in whatever manner they may be placed, still, between and among them, graves may always be formed. There is a specific objection against boundary belts, which is, that they occupy a space that might be advantageously laid out as a broad border for tombs of a superior description, with a gravel walk in front accompanied by another border on the opposite side. For the same reasons that we would not introduce trees and shrubs in masses, we would not, in the case of cemeteries on low or level ground, plant trees which produce bulky heads; but confine ourselves chiefly to kinds having narrow conical shapes, like the cypress, the form of which not only produces little shelter or shade, but has been associated with places of burial from time immemorial. Almost all the kinds should be evergreen and of dark foliage; because the variety produced by deciduous and flowering trees is not favorable to the expression either of solemnity or grandeur. Evergreen needle-leaved trees, such as the pines, firs, junipers, yews, &c., we should prefer; because, when their foliage drops, it produces much less litter than that of broad leaved trees, such as the holly, common laurel, evergreen oak, &c. On very hilly cemeteries we would introduce round-headed trees along with conical shapes, but still chiefly confining ourselves to evergreens, such as the ilex, Lucombe oak, holly, the dark-foliaged pines, &c.

Supposing all the roads, walks, and green paths laid out, or their situations fixed on, and all the beds and borders also laid out, then we would dispose of the trees and shrubs in the following manner. Along each side of most or all of the main roads, whether straight or curved, we would plant a row of trees parallel to the road, and at regular distances, so as to form a running foreground to the interior of the compartments, and to whatever there might be of distant scenery. The kinds should be pines and firs of dark foliage. In roads and walks in the direction of east and west, we would either plant the trees farther apart, or plant narrower-growing kinds, such as the common cypress, the Irish yew, the Swedish juniper, the fastigiate abor vitæ, &c. At many of the intersections of the squares, in those cemeteries where that mode of division is adopted, we would plant provisionary trees, of a kind strikingly different from every other planted in the cemetery, in order to distinguish the angles of the squares at first sight, with the number-stone at their base, to be taken up when it became practicable, or desirable, to substitute obelisks, square pillars, or other monuments, for them. Along the centre of the beds adapted for double rows of graves, we would plant trees or shrubs at regular distances, with the intention that, in this and in all other cases, whatever, except along the main approach from the

entrance to the chapel, the trees should be taken up and replanted, or removed altogether, when necessary, so as to suit the position of the graves.

With respect to the kind of trees, we would, with very few exceptions, plant only those evergreens which have naturally dark foliage and narrow conical heads, or which admit of being pruned with little difficulty into such form; because, such forms not only interfere less with ventilation, sunshine, and the performance of funerals, but, more especially when of a dark color, are naturally, from their great height in proportion to their breadth, more sublime than spreading forms; as well as artificially so, from their being classically and popularly associated with places of sepulture. For the main avenue we should prefer *P*inus taúrica, *P.* Pallas*iàna*, or *P.* nígricans; if the situation were favorable, the evergreen cypress, or the Juníperus excélsa, found to be a very hardy conical tree; and, if very unfavorable, the red cedar, or the common spruce. The pines and spruces grow rapidly, and admit of being cut into cones as narrow as may be desirable; but, to render this cutting unnecessary, the red cedar, and some of the rapid-growing conical junipers, might be employed. Along most of the gravel walks, and along the centre of the double beds, we would plant, for the most part, only fastigiate shrubs, such as the Irish yew, Irish and Swedish juniper, *J*uníperus recúrva, and some other junipers, and the arbor vitæ, box, common yew, &c. We would not plant, as a part of a general plantation of a cemetery or churchyard, weeping willows, weeping ashes, weeping elms, or trees of that kind; because we think that these trees, being of such marked and peculiar forms, are best adapted for being used only occasionally, for particular purposes; and, therefore, we would leave individuals to select such trees, or trees or shrubs of any other singular shapes that they thought fit, and have them planted over their graves or tombs. Thus, while the general plantations of the cemetery maintained a uniform grandeur and solemnity of expression, the singularly shaped trees and shrubs employed by individuals, would confer variety of character.

A cemetery planted in the manner described, will have a distinctive character, and one quite different from that of any of the cemeteries that we have seen, either in London or elsewhere. The cemeteries, according to our ideas, bear too great a resemblance to pleasure-grounds. That they are much frequented and admired by the public, is no proof that they are in appropriate taste, but only that they are at present the best places of the kind to which the public have access. When our public parks and gardens are extended and improved as they ought to be; when they are ornamented with fountains, statues, immense blocks of different descriptions of rocks, (named) and with models of celebrated buildings, as covered seats and places of temporary repose or shelter; when they abound in singing and other birds, and aquatic fowls, and contain every variety of tree and shrub that will thrive, and many kinds of herbaceous plants; and when they are perambulated, during a certain number of hours every summer's day, by a band of music, as in some of the public gardens in Germany;

then will the necessity, as well as the propriety, of having a distinctive character for cemeteries be understood and appreciated.

The planting of *flowers* in cemeteries is very general, not only in the margin of masses and belts, and in beds, as in pleasure-grounds, but on graves. For our own particular taste, we would have no flowers at all, nor any portion of ground within a cemetery that had the appearance of being dug or otherwise moved for the purpose of cultivation. A state of quiet and repose is an important ingredient in the passive sublime; and moving the soil for the purpose of culture, even over a grave, is destructive of repose.

Nevertheless, as the custom of planting flowers on graves, is common throughout Europe, and of planting them in beds is frequent in the cemeteries about London, arrangements for this purpose must be provided accordingly. We would never plant flowers or flowering shrubs in the margins of masses or belts, or in beds or patches that might be mistaken for those of a lawn or a flower-garden; but, to give them a distinctive character, we would plant them in beds of the shape of graves or coffins, raised above or sunk beneath the general surface, and only in situations and on spots where at some future time a grave would be dug. For example, two graves are seldom dug close together, but an intervening piece of firm ground is always left of width sufficient for forming a grave at a future time; the object being to have, if possible, at all times, firm ground for the sides of a grave which is about to be excavated. Now, on these intervening spots alone would we plant beds of flowers, or of roses, or of other flowering shrubs. When flowers, shrubs, or trees are planted on occupied graves, it is done by individuals according to their own taste. The most highly ornamented cemetery in the neighborhood of London, as far as respects plants, is that of Abney Park, in which as already mentioned, there is a complete aboretum, including all the hardy kinds of rhododendrons, azaleas, and roses in Messrs. Loddiges' collection; and in which also dahlias, geraniums, fuchsias, vebenas, petunias, &c., are planted out in patches in the summer season.

To be Continued.

Description of the Roofs over Buckingham Palace, covered with Lord Stanhope's composition. By Peter Hogg, Assoc. Inst. C. E.

The mixture invented by Lord Stanhope, and used by the late Mr. Nash, for covering the nearly flat fire-proof roofs of Buckingham Palace, is described in the paper as being composed of Stockholm tar, dried chalk in powder, and sifted sand, in the proportions of three gallons of tar, to two bushels of chalk, and one bushel of sand, the whole being well boiled and mixed together in an iron pot. It is laid on in a fluid state, in two separate coats, each about three-eighths of an inch in thickness, squared slates being imbedded in the upper coat, allowing the mixture to flush up between the joints the whole thickness of the two coats, and the slates being about an inch. The object in imbedding the slates in the composition, is to prevent its

becoming softened by the heat of the sun, and sliding down to the lower part of the roof, an inclination being given of only 1¼ inch in 10 feet, which is sufficient to carry off the water, when the work is carefully executed. One gutter, or water-course, is made as near to the centre as possible, in order to prevent any tendency to shrink from the walls, and also that the repairs, when required, may be more readily effected. It is stated, that after a fall of snow it is not necessary to throw it from the roof, but merely to open a channel along the water-course, and that no overflowing has ever occurred; whereas, with metal roofs it is necessary to throw off the whole of the snow on the first indication of a thaw. These roofs have been found to prevent the spreading of fires, and it is stated, that on one occasion, to test their uninflammability, Mr. Nash had a bonfire of tar barrels lighted on the roof of Cowes castle. Another advantage is stated to be the facility of repair which the composition offers, as if a leak occurs, it can be seared and rendered perfectly water-tight, by passing a hot iron over it; and when taken up, the mixture can be remelted and used again. The author proposes to obviate the disadvantage of the present weight of these roofs, by building single brick walls at given distances, to carry slates, upon which the composition should be laid; instead of filling the spandrils of the arches with solid materials, as has been hitherto the custom.

The reported failures of this species of covering at Mr. Nash's house in Regent street, and in other places, are accounted for by the composition having been used in one thin coat, laid upon an improper foundation of laths and tiles. The durability of the roofs, which were carefully constructed with good materials, has been, it is contended, fully proved at Lord Palmerston's house, which was covered with the composition in 1807; Lord Berwick's, in 1810; Sir James Langham's, in 1812; the Pavillion, at Brighton, in 1816 and 1823; and nearly the whole of Buckingham Palace, in 1826 and 1829; the latter roofs are stated to be in perfect order at the present time, and have scarcely demanded any repairs since their completion.

Remarks.—Mr. Poynter presented a drawing of the mode of setting the pots for melting and preparing the composition, the proportions of which he stated somewhat differently from those given in the paper. Three measures of ground chalk, dried and sifted very fine, were mixed and kneaded up with one measure of tar; these ingredients were melted in an iron pot, set in such a manner that the flame should not impinge too violently upon it. The first or "skimming" coat of the covering being laid on of a thickness of $\frac{3}{16}$ inch, the finishing coat was composed, by adding to the former mixture, three measures of hot sifted sand, well mixing the whole together; the composition was laid on with a tool similar to a plasterer's trowel, but much stronger. Mr. Nash, when he first tried the composition, found that the surface became disintegrated by exposure to the weather; he, therefore, added the slates imbedded in the second coat, and subsequently never used the mixture without them.

Mr. Nixon, in reply to questions from the President and other members, stated, that he was employed under Mr. Nash when the

palace roofs were executed, and he could bear testimony to their durability and soundness. The roofs at East Cowes castle, which were covered with the composition in the year 1808, and those of the Pavillion, at Brighton, in 1816, were now in as good a state as when they were finished. The failure at Mr. Nash's house, in Regent street, arose from the roof having been originally composed of mastic, which soon cracked. One coat of the Stanhope composition was spread over it, to stop the leaks, but it was insufficiently done, and ultimately Mr. Rainy had a new roof, properly constructed, with two coats of composition, which had remained sound to the present time. The price of these roofs, when well constructed by the person who did those of the palace,* was about five guineas per square.

Mr. Hogg observed, that the chalk was only exposed to such a heat as would evaporate any moisture it contained. The weight of the two coats of Stanhope composition, including the slate imbedded in it, was about 12 lbs. per superficial foot.

Mr. Sibley considered the Seyssel Asphalte, when carefully laid, preferable to any composition of a similar nature; he had used it extensively, and was well satisfied with it, both for roofing and paving.

Mr. Hogg objected to the use of asphalte for roofing, as it was liable to injury, being of a brittle nature; it was not elastic, and it shrunk from the walls, thereby causing leaks. Lord Stanhope's composition did not possess these faults, and he did not consider that it was superseded by asphalte.

Mr. Moreland had covered the roof of the tread-mill, at Giltspur Street Compter, with asphalte, and had found it answer perfectly. It was laid on in a thickness of $\frac{3}{8}$ inch upon roofing boards $\frac{3}{4}$ inch thick, with canvas nailed on them, with an entire fall of only 9 inches; there was not any appearance of leakage.

Mr. Davidson had caused a school-room to be floored with asphalte, four years ago, and up to the present time, there was no symptom of wearing down, although the stones which were let into the floor, for supporting the desks, &c., were considerably abraded. He believed that the only failures of the asphalte had occurred from the use of inferior ingredients. Gas tar had been used instead of vegetable tar, and in those cases the result had not been successful.

Civ. Eng. & Arch. Journ.

Mechanics and Chemistry.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Strength of Cylindrical Boilers. By THOMAS W. BAKEWELL, Esq.

A communication from me on the above subject, appeared in the January number of this journal. Prompted by a report on the explosion of a boiler in the steamboat Medora, and composed by Mr.

* Mr. Millson, No. 6 Frances Street, Tothill Fields, Westminster.

B. H. Latrobe, at the request of the Committee on Publications, for the Journal of the Franklin Institute.

The subject and the error with which it is, by authority, burthened, occasioned my remarks, without any special reference to the Medora's boiler, or the opinions as held by the author of the report, for they (the opinions) are truly orthodox, and would have formed the basis of a report on the same matter, by nearly all, professionally, scientific men.

Many years have not passed, since the advocates of loss of power by the "crank motion" stood on equal ground with their opponents. Fewer years have passed since those who contended for a loss of power by the alternating weight of a lever beam and its appendages, when working through the intervention of a crank, stood on higher ground than those of an opposite opinion; and I well remember the time, when my ideas, especially on the latter branch of the subject, were considered fatally heretical.

I believe I am now safe in saying, that the crank and the lever beam have found their proper places; and most assuredly the cylindrical boiler, will, also, ere long, assume its correct position. I rejoice that my communication, above referred to, has elicited notice. Mr. Latrobe has replied to it in the June number of this journal, which this is intended to meet. The question before us, is, whether steam of a given density, in a cylindrical boiler, exerts a force to rend or part said boiler at any one and every point of its circumference, with a force equal to the pressure which the steam would give, on a space equal to the semi-diameter of the boiler, or a space equal to the quarter circumference—making a difference as 1. to 1.57. The sanctioned and received rule gives the former, while I contend for the latter.

Let it be recollected that the upper and lower points of the boiler, are selected as the points of investigation, merely because they are of easy reference, and that a quarter of the circle only requires to be considered for any one point, as it embraces all the varieties of direction, from vertical to horizontal.

Mr. Latrobe states that "no force oblique to the direction pursued by the body to which it is applied, can operate with its full intensity upon that body; but must expend a portion of its energy upon some other object."

Undoubtedly if that other object be foreign to, and independent of, the body originating the force; but with the boiler, the obliquity, as well as the direct action, must be disposed of within itself, we cannot form the statical triangle without an object distinct from the boiler. When opposing forces are oblique to each other, the primary force governs, and the derivative or resistance, has the obliquity—then, *the required intensity of resistance, to balance a given force, is proportional to its obliquity with that force.*

Mr. L. continues, "Mr. Bakewell's error seems to me to consist in losing sight of this elementary truth, for in using the semi-circumference, instead of the diameter, in his estimate of the pressure, at the extremities of the latter, he omits the resolution of the radial forces into their operative and inoperative elements, and assumes them to

act with their full intensity to tear the cylinder asunder, notwithstanding the greater or lesser obliquity of every one of them, excepting the single central one, perpendicular to the diameter."

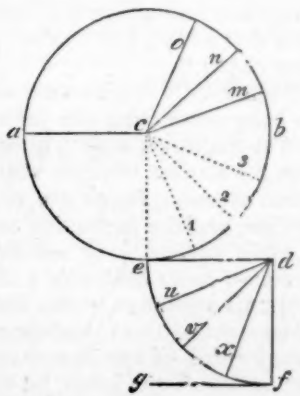
I have not lost sight of this circumstance. The "operative" force at any one point, is, (I suppose) on the received rule, as cosine to radius of the boiler; and for any given space on the circumference, as the vertical base of that space.

Having referred to the crank, permit me to make further use of it, and to observe that this 57 per cent. of difference in our estimates, happens to be the exact amount of mechanical effect which the crank would gain over its present mode of acting, provided the power throughout its circle acted on it at right angles, as it now does at two points only. Or, perhaps, more familiarly to my readers, there is a loss in the present mode of action of 37 per cent. on the 1.57 which *would* be the effect, if, as above, supposed.

As before stated, a quarter of the circle, whether of crank or boiler, is sufficient for illustration of the principle sought. Then let the connecting rod (indefinitely long) from a cylinder, be attached to a crank at right angles, and a series of *other cranks*, project at equal and indefinitely small distances from the same centre through the greater circle; let each and every of the cranks be equally impressed with a given force at right angles to each respectively, then the required resistance on the piston, to oppose and hold these cranks in equilibrio, would be the sum of the pressures on the cranks.

Here we have uniform powers distributed over, and represented by, the greater circle, and conforming to its various directions in *one* direction, represented by a line equal to the semi-diameter, or half stroke, and the obliquities of the resistances and consequent increased intensities, represented by the difference in length inversely (or of motion supposed) between said resistances on the semi-diameter, and the powers on the quarter circle.

The radial action of the steam on any one point, for instance, at the bottom of the boiler, may be viewed in this wise. The boiler may be considered as suspended at *a* and *b*, by the pressures on the upper or opposite half, if you please, (which is true) and the radial force at *e*, acting downwards, through the curved arm, or lever *e*, *a*, the *virtual* length of which is only as *a*, *c*, equal the semi-diameter. By tracing the radial force back and upwards from *e*, by the dotted line *e*, *c*, to its supposed source at *c*, this *virtual* lever is met, and the action becomes apparent; and for each point of radial action on the boiler, shown by the dotted lines, the resting point of the lever so formed, will in like manner be at right angles to such radial force, as 1.*m*—2.*n*—3.0.



Thus we have a series of cranks or levers with varying points of rest, and the force always at right angles. These cranks and their combined effect may be shown concentrated, by having a common centre or point of rest, as at *d;* then *u, v, x,* represent levers or cranks, *m, n, o,* respectively, with the several equal forces of corresponding directions at right angles to them.

Now, if the whole quarter circle *e, f,* were filled or occupied by cranks under like conditions, the sum of their forces would be expressed by the said quarter circle *e, f,* and the required horizontal resistance to balance them, if represented by or on the line *g, f,* equal to the semi-diameter, must compensate by intensity what it is deficient in length (or motion supposed).

Mr. L. offers as illustrative of the fallacy of my position, that a ring of iron one inch in width, be filled by a solid disk of some hard body, also one inch in thickness; then divide the disk equally in two parts, and let a wedge be driven with a certain force tending to separate them, or he adds, "what would be better," to introduce steam into the fissure. With steam in the fissure, the disk and ring fall short of making a parallel case. It is plausible, so far as the circular form is preserved, and it is evident that the force to part the ring at top and bottom, would be no more than the pressure on the diameter. But the ring is not under the same conditions as with steam alone; in the latter case, the force acts in all directions with the disk; it is confined to one direction (say horizontal), and it is immaterial whether the steam be prevented from acting upwards and downwards (or largely partaking of those directions), by the interposition of a solid body, or that the force of the steam should be conteracted in those directions by vertical ties. The rule of the force to part, being as the diameter, would be good in either case. The ring near the horizontal ends of the disk, would be in effect converted into a stiff or solid material, losing its flexibility. With the disk, the ring is not under so much pressure outwards near the top and bottom, as with steam, notwithstanding its retention of the circular form; for if the steam were admitted between the ring and the disk—say as far as an angle of 30° on each side the vertical fissure—the top and bottom would be distended, the vertical fissure closed, and the ring cease to be circular; and if the fissure were made of sufficient width not to impede the distention at top and bottom, the ring would be held by the steam acting as above, in equilibrio of an irregular, oval figure.

This last assertion may require some strengthening, which I will endeavor to furnish. Imagine a square, the upper and lower sides of sheet iron, and the vertical sides of strong cast iron, and all the sides may be supposed of one inch in width, as with the ring; then subject the square to the action of the steam. If the upper and lower sides were perfectly flexible, and at the same time unyielding lengthwise, any force, however small, by the steam, would compel the approach of the cast iron sides, however strongly propped apart, or breakage of some part must ensue;—such is the extreme of the theory. Practically, it is enough to say that by the force of moderate steam, the sheet iron top and bottom would each be distended into a figure

approaching to a large sequent of a circle, and the cast iron sides proportionally drawn together.

This singular figure, in the aggregate of an oval form, having a flat place in each of its longer sides, would be held balanced and at rest by the contained steam—which diameter would my opponents take, in computing the parting force?

I shall not venture on the field of speculation here opened, lest an error in a collateral branch of the subject might unjustly taint the now important one at issue.

As to the fact of the upward and downward pressures on the sheet iron sides, being more effective than the lateral pressures on the cast iron sides, I shall limit myself to the repetition of a remark in my first communication, that they (the sheet iron sides) sustain the pressure *"in the disadvantageous manner of a string stretched horizontally bearing weight."*

Is it more than fair that the ring and disk be now presented by me, as an exposition of the received theory, by which, as I have formerly said, "the horizontal action of the steam is alone considered," and showing its insufficiency to fulfil the actual conditions of the case. Before closing this article, let me put the following simple question: A weak place is in the boiler at top or bottom,—will a *vertical* tie near it, support, or relieve the weak place from a portion of the parting strain? if yea, what is the rationale? By the tenor of the latter part of Mr. L's. paper, I would fain hope that he is almost pursuaded to be a heretic. Were he so altogether, his loss of caste by the convertion, would endure but for a season.

Cincinnati, 27th June, 1843.

On the Blowpipe. By Theo. F. Moss, Mining Engineer.

(Continued from Vol. V, page 287.)

After examining a substance in a glass tube, and in a tube closed at one end, another portion of the substance must be heated, held in platina pincetts, before the flame of the blow-pipe, to see if it is fusible and to what degree; and for this purpose a scale recommended by Kobell may be used with advantage. This scale is, 1. grey Antimony ore, which melts in a common flame; 2. Natrolite, which melts in fine splinters in the inner flame, and in large pieces easily before the flame of the blow-pipe; 3. Adular does not melt in the flame of the lamp, but easily before the blow-pipe flame; 4. Almandine melts with difficulty before the blow-pipe flame; 5. Augite melts with more difficulty than almandine, but easier than 6. Bronzite, which can only be fused before the blowpipe on the edges of the finest splinters. It is advisable to have splinters of these minerals at hand for the sake of comparison, and the difference of fusibility of any mineral between any numbers of the scale is computed in decimal places, in the same manner as in determining the hardness. The relative fusibility of minerals, is of great use in determining the silicates from one another, which generally have the same chemical reactions before the blow-

pipe, but have different degrees of fusibility. Care must be taken to use fine splinters of the mineral, as by using thick pieces, a mineral often seems infusible, when in reality it can be fused with ease; and with little practice the degree of fusibility of any mineral, as compared with the scale, can easily be determined.

Minerals heated in the platina pincetts often color the flame, in which case in order to determine correctly the color, a pure blue flame must be blown, and the mineral held at the edge of the flame, and thereby the presence of some substance may be determined with great certainty. An intense violet flame is produced by potassa; but if the same mineral contains soda or lithia, the flame will be colored either yellow from the soda, or red from the lithia. A green flame is produced by sulphate of barytes, the ores of telluriam, and some of the ores of copper. Many of the compounds of sulphur, arsenic, and antimony cause a pale, bluish-green flame. A beautiful blue is produced by the muriate of copper, muriate of lead, and seleniuret of lead.

After having heated a substance in the pincetts, it is laid on curcuma paper, and wet with a drop of water, and if the paper is colored brown, or brownish red, it shows an alkaline reaction, this alkaline reaction is shewn by all the combinations of the alkalies and alkaline earths, with carbonic acid, sulphuric acid, nitric acid, muriatic, and fluoric acid, and with water.

After having thus examined the substance, the mineral is to be examined on charcoal; if the substance is in powder, it must be made into a thick paste, and put on the coal. Most of the metals melt in the coal before the blow-pipe flame, and are oxidized, except gold and silver; platina, iridium, palladium, rhodium and osmium, are infusible.

Molybdinum, wolfram, nickel, and iron, are also infusible; their oxides can, however, be reduced by the inner flame. Most of the sulphates are fusible on coal, and are mostly changed to the oxides when sulphurous gas is disengaged. Most of the metallic oxides are infusible before the blow-pipe, but are generally more highly oxidized by the outer, or deoxidized by the inner flame. The following few oxides are fusible: the oxide of lead, bismuth, antimony and copper.

Salts soluble in water, melt before the blow-pipe flame on coal, but are mostly decomposed and leave their base on the coal. The alkaline salts are either drawn into the coal, or melt into a bead; most of the insoluble salts melt into a bead, which, on cooling, becomes crystalline.

Some substances on being heated on charcoal, undergo a change of color, by which they may be easily recognized; zinc oxide is white when cold, but becomes yellow when heated; and the original color of many substances when heated becomes much darker. A very important means of knowing minerals is their sublimate, that is, the volatile oxide which is deposited on the coal around the mineral when heated in the oxidizing flame. A white sublimate is formed by tin, zinc, antimony, arsenic and tellurium; the sublimate of tin is thick, and can be reduced by the inner flame; the zinc sublimate is, when warm, yellow, but on cooling, white, and burns with a white phosphorescent flame; if cadmium is present, the zinc sublimate is surrounded by a dark

yellow sublimate of cadmium oxide; the sublimate of antimony is also thick, and volatilizes where it is touched by the blow-pipe flame; the sublimate of arsenic is white, in thin layers greyish, and far from the mineral, and can be volatilized by slightly heating; the sublimate of tellurium is white, but has a red or dark yellow edge, and vanishes on being blown on by the reducing flame, with a green appearance.

The sublimates of lead, bismuth, and cadmium are very similar; the sublimate of bismuth, is, when warm, dark orange yellow, when cold, lemon yellow, and in thin layers blueish, and can be driven from one place to another by the blow-pipe flame, when it is partly volatilized; the sublimate of lead, is, when warm, dark lemon yellow, cold, sulphur yellow, and in other respects like the sublimate of bismuth; the sublimate of cadmium is to be seen plainly only when it is cold, its color is yellowish brown, and in thin layers, yellow, and can be volatilized by any flame.

Silver melted on coal in the oxidizing flame, gives a slight dark red sublimate; when lead is present, the coal is at first covered with the sublimate of lead, and afterwards with the sublimate of silver.

After having examined the mineral before the blow-pipe without reagents, and no satisfactory results obtained, it must be examined with reagents, which must be chemically pure, otherwise false results will be obtained.

The reagents which are used, are:

Soda, and must, in particular, be free from sulphuric acid; borax, which must fuse into a transparent colorless glass; phosphate of soda, which must also fuse into a colorless glass; saltpetre, boracic acid, powdered fluor spar, a solution of nitrate of cobalt, which must not be very concentrated, and must be free from alkaline substances; tin, iron in the form of fine wire, lead, oxide of copper, litmus, and tumeric paper.

The relation of the mineral to borax or phosphate of soda, is to see its solubility, and the color which the discolored substances give to a bead of borax or phosphate of soda in the oxidizing or reducing flame. This reaction is of great importance for metallic compounds.

Most of the combinations of manganese give when melted with borax or phosphate of soda, a glass which in the oxydizing flame is violet red, but in the reducing flame becomes colorless.

All minerals containing cobalt give these fluxes a saphire blue color; chromium gives an emerald green glass with these fluxes.

The oxide of iron and most of the minerals containing iron, give these fluxes in the oxidizing flame, a dark red color, which, on cooling, becomes paler, then yellow, and when quite cold, is colorless; in the reducing flame the glass is bottle green, and remains so when cold.

The oxide of cerium gives in the oxidizing flame with borax, a red or dark yellow glass, which, on cooling, becomes paler; in the reducing flame the glass is colorless.

The oxide of nickel gives with borax in the oxidizing flame, when warm, a violet brown glass, which, on cooling, is red brown; in the reducing flame the color disappears, and the glass becomes greyish

from small particles of reduced nickel; with phosphate of soda, the reaction is the same in the oxidizing and reducing flame, as with borax in the oxidizing flame.

The oxide of copper gives with borax and phosphate of soda in the oxidizing flame, a light blueish-green glass; in the reducing flame a brownish red, generally cloudy and opaque.

The oxide of uranium gives with borax in the oxidizing flame, a dark yellow glass, which in the reducing flame is a dirty green; with phosphate of soda, in the oxidizing flame, the glass is clear yellow, in the reducing flame a beautiful green, which becomes more apparent on cooling.

Molybdic acid gives with borax in the oxidizing flame, a colorless glass, which becomes brown in the reducing flame; with phosphate of soda, in the oxidizing flame, the glass is green, but, on cooling, becomes paler; in the reducing flame it is dark, but, on cooling, becomes a beautiful green.

Wolframic acid gives with borax, in the oxidizing flame, a colorless glass, which in the reducing flame is yellow, by a greater addition of wolfram, it becomes, after cooling, a blood red; with phosphate of soda, in the oxidizing flame, the reaction is the same as with borax; but in the reducing flame, the glass bead becomes of a beautiful blue color, when the acid is free from iron, but when iron is present, the glass is blood red.

Titanic acid with borax, gives with the oxidizing flame, a colorless glass, which in the reducing flame, becomes a dirty amethyst color; with phosphate of soda, with the addition of a little tin, in the reducing flame, the bead is of a blue violet color, but when iron is present, the color is red.

The other metallic oxides color the glass beads of borax and phosphate of soda, either not at all, or yellow; the earths also do not color the fluxes, but are all soluble in them except silica, which is not soluble in phosphate of soda.

In order to prove the presence of fluorine in a mineral, a small quantity of it is melted with phosphate of soda in the end of a glass tube, when hygrometric fluoric acid is formed, which destroys the glass.

To prove the presence of chlorine in a mineral, take a bead of phosphate of soda, charged with oxide of copper, so that the bead is strongly colored with the copper, then add the mineral, and if it contains chlorine, the flame will be of a beautiful blue. Bromine and iodine have the same reaction, but bromine colors the flame bluish green, and iodine pure green.

From the above it will be seen that no two oxides have the same reaction with borax and phosphate of soda, in both the oxidizing and reducing flame; therefore, it is necessary in all cases to examine the mineral with both fluxes.

On the reaction with Soda.

When a substance is treated with soda, the two are generally melted together on coal, the substance is either applied in splinters or in

powder, and the soda gradually added. A great many substances have the property of uniting with soda at a high temperature, and combinations are formed of which some are fusible, and some infusible. However but few belong to the fusible, viz., silica, and a few metallic oxides, viz., the wolframic, titanic, and molybdic, which, with the exception of the combinations of silica, are mostly drawn into the coal.

In order to try the fusibility of a substance with soda, if the substance is in the form of a powder, a paste is made with it and some soda; but if it is in splinters, it is covered with a paste of soda, and laid in a small hole in the charcoal, and at first slightly heated to drive off the water, and then strongly heated with the oxidizing flame; at first, when the soda begins to fuse, it is drawn into the coal, but makes its appearance again when it begins to unite with the substance, when it fuses with effervesence into a ball; but if the substance is insoluble in soda, but decomposed by it, it changes its appearance, and does not fuse into a ball.

If a substance is soluble in soda, and not enough soda has been added, a part of the substance remains undissolved, and is surrounded by a clear glass; but if too much soda has been added, the glass, on cooling, becomes opaque, therefore, it is advisable always to add the soda in small proportions, in order to see the changes which are produced by the addition of greater quantities.

A substance which is soluble in soda, if it contain sulphur or sulphuric acid, gives the glass a yellow red, or yellow brown color, according to the greater or less proportion of sulphur in the substance.

If a substance soluble in soda, is in the form of powder melted with soda on platina foil, and the fused mass has a bluish green color, it shows the presence of manganese.

If the mineral contains silica and the oxide of cobalt, the silicate of soda is formed, which will be colored blue by the oxide of cobalt.

By the reduction of metallic oxides by the aid of soda, the presence of metals in minerals, if contained in small quantities, can be detected with more accuracy than by analysis by the wet way.

If a metallic oxide is in combination with substances which render its reduction difficult, and the reduced metal difficult of determination, the mineral must be reduced to a fine powder and mixed with soda to a paste, and melted on coal before the reducing flame. The first of the soda is generally drawn quickly into the coal, therefore, it must be continually readded till no more of the assay remains on the surface of the coal. The first part of the soda serves to collect the metallic contents, and the latter to reduce the metallic oxides. After the reduction of the mineral, the part of the coal where the reduction took place, must be wet with a few drops of water, and all that part of the coal which is saturated with soda, cut out with a knife, and rubbed in an agate mortar with water to a fine powder, and slowly triturated that the coal and unreduced substances may separate easily from the more heavy metallic particles, and be easily drawn off with water from these. This must be continued till all but the metallic parts are removed from the mortar. If the mineral does not contain a reducible

metal, the mortar will be empty, but if it contains only a small quantity of such a metal, there remains at the bottom of the mortar, shining flat spangles of the metal, if the metal was easily fusible and malleable; but a metallic powder if the metal was hard to be fused or not very malleable.

In this manner we may very plainly detect one-half per cent. of tin, and a still less proportion of copper in a mineral; if several metallic oxides are contained in the same mineral, they are generally reduced together to an alloy, sometimes separate reguli of each mineral are given.

The metals which in this manner may be reduced are molybdinum, antimony, wolfram, tellurium, copper, bismuth, tin, lead, zinc, nickel, cobalt, iron, silver and gold. Among these are some which are either totally, or in part, volatilized, and cover the coal with their oxides; to these belong antimony, tellurium, bismuth, lead and zinc: arsenic, cadmium and quicksilver are also reduced with soda, but are again immediately volatilized, and can only be obtained in a metallic form by sublimation with soda in glass tubes.

If, in reducing with soda, a metallic regulus is obtained, which is an alloy of several metals, it must be handled with borax or phosphate of soda, in the manner already described.

To be Continued.

On the Ores used at Freiberg.—Translated from the German of C. A. Winkler. By Theo. F. Moss, Mining Engineer.

At present between 180,000 and 190,000 cwt. of ore are used yearly at the works of Freiberg; of which from 60 to 70,000 cwt. are used in the amalgamation works, and the rest worked up in the furnaces.

With few exceptions all the ores are brought from the numerous mines of the Freiberg mining district, and are in a powdered form.

These ores are, in relation to their component parts, of great variety. The quantity of silver in a cwt. of ore, varies from 0 to many 100 ounces in the cwt., and some of them are of the richest description of silver ores, but the average amount is between 2 and 3 ounces to the cwt.

Some of the ores are more or less rich in lead, but the quantity of lead ores which contain more than 30 per cent., is hardly $\frac{9}{100}$ of the whole mass of ore; copper ores which contain several pounds of copper in the cwt. are but few; but traces of copper are found in most of the ores, therefore the silver from the amalgamation process always contains some copper, although the copper ores are never at Freiberg, used in the amalgamation works. About 14 to 18 per cent. of the whole quantity of ore is either poor in silver, or totally free of it, and is iron pyrites, used in the first smelting process.

The other component parts of the Freiberg ores are very various, as is to be expected from the various and numerous veins from which the ores are brought. The ordinary mixtures are quartz, hornstone

jasper, heavy spar, and calcareous spar; fluor spar, on the other hand, is at present but seldom met with. Iron pyrites is common, but is not at hand in sufficient quantities to supply the necessary addition for the first smelting; some of the ores contain a great deal of zinc, antimony or arsenic, and iron ochre and carbonate of iron are found in greater or less quantities.

The Freiberg ores belong, on the whole, to that class of ores which are with difficulty smelted, and the most infusible kinds are those which are composed in most part of quartz or heavy spar.

It is worthy of mention that some gold is found in most of the Freiberg ores, and appears to be contained in the pyrites. The per centage of gold is, however, so trifling, that it would not cover the cost of separation. A small profit would accrue from separating the gold from the silver obtained by the smelting process from some varieties of the pyrites, were it not found more profitable to use these ores in the amalgamation, when most of the gold is lost in the reviving process *(anquickprozess)* without being concentrated in the silver amalgam.

The ores used in the amalgamating works must neither contain lead nor copper. Lead would make the amalgam impure, and the lead would be lost in the residuum; copper ores by the Freiberg amalgamation process would cause the silver to contain too much copper, and much of the copper would also be lost in the residuum.

Therefore, the ores which are used for the amalgamation *(verquickung)* contain as little lead and copper as possible, and from 3 to 4 ounces silver to the cwt. of ore, but at the same time sufficient pyrites for the decomposition of the salt used.

All other description of ores, whatever may be the proportion of silver, lead, copper or pyrites, are given over to be smelted at the furnaces.

Experiments and Observations on Möser's Discovery, proving the Effect is neither due to Light nor Heat. By Horatio Prater.

(Continued from Page 72.)

6. *As regards Impressions on Glass.*—We have already observed that heat does not seem to increase the effect of *metal* coins on glass. Neither did *long contact;* for a fourpenny piece, left a *week* on a piece of looking-glass, only left the usual spectrum, no *figure* being visible. The same remark applies to large *printed* letters. At least, some paper with these, after remaining pressed two or three days without giving any impression, was then heated for five hours, so pressed, at about 160°, but no impression was made. On another occasion, print and writing were left a week on a glass mirror without leaving an impression. When, however, thinner paper and larger letters were used, and heat and pressure applied as above for four or five hours, these letters were plainly visible; but, as appeared to me, far more easily erased than were the spectra of coins on copper plates.* A

* On a copper plate also this *thin paper* (not being well dried first) gave a permanent and very visible spectrum, the lettering being clearer than on glass: not due to oxidation, *i. e.*

slight touch of the finger, for instance, erased the letters in question. They were produced in this case in consequence, no doubt, of the thinner paper being *moister* than that first used.

Heat does not appear to increase the effect on glass. A fourpenny piece under a shilling for three hours, at 160°, left no spectrum.

On putting a penny on a sovereign, and leaving them for three hours and a half at the above heat, I thought the spectrum of the penny slightly visible; but as the image is never so apparent as on polished metal, I shall not venture a decided opinion on this point as regards glass.

A *polished*, *boiled*, and then well dried half-crown, gave as good a spectrum on a glass plate in twenty-four hours, as did a dirty half-crown; but I thought the spectrum of the former disappeared sooner by breathing. On a far thinner glass plate, a bright, boiled four-penny piece, left the same time, gave no spectrum at all.

7. *Polished surfaces not appearing capable of receiving the impressions.*—These exceptions from the general rule I have found to be talc, and among the metals tried, steel to a certain extent, platinum and gold.

Whether heated or not with the coins on it, I have found *no* spectrum produced on talc, except in one instance, where a tarnished half-sovereign had been pressed some days by a half pound; and even here the mere margin of the coin was *barely* perceptible.*

On steel, after remaining twenty-four hours, I found a *very* slight evanescent spectrum produced by a small piece of brass, and on *one* occasion by a half-sovereign very much tarnished; but as heat did not appear to increase or hasten the effect, we may consider steel almost unsusceptible. The spectra just named disappeared entirely after breathing *twice;* and no *permanent* spectrum was produced, though the piece of brass above mentioned was placed even on the top bar of a grate, and, of course, kept very hot, for two or three hours.

Under the head "Thinness of the plates," experiments, showing the incapability of platinum to receive images are mentioned.

The same remark applies also to gold. I kept a shilling and a farthing on two different occasions, for twenty-four hours or longer, on a well polished plate of gold, yet they *barely* left a marginal spectrum; and this spectrum, as in the case of steel, disappeared *entirely* on breathing on it twice. As the gold used was not free from the usual alloy of copper, possibly this was the cause of its receiving even the very slight spectrum it did. However this be, these experiments seem almost sufficient to establish the important general principle, viz., *that the less metals are oxidable by exposure to the air, the less is their susceptibility to receive spectra.*

oxidation in the usual sense of the term; but, on rubbing it off, the surface of the copper was left polished; there, no doubt, was some *very slight* chemical action, as large printed letters on perfectly well dried paper were not taken off on a copper plate, the heat at 160° being applied for five hours; or on another occasion, the print remaining a week on the plate, and pressure being used.

* Talc, like platinum, is not easily acted on by acid.

8. ***As regards comparative polish in metals.***—1. A new sovereign, a new half-crown, and a new farthing (all well polished) were kept on a bright copper plate, at 160° or above, on *two* successive occasions, for four or five hours. The gold and silver left only *very* slight permanent traces of their margin, the copper left none at all; but its spectrum, when the plate was breathed on, became, I thought, even rather more evident than the spectra of the gold and silver, these being likewise breathed on. 2. A *tarnished* sovereign and a *tarnished* half-crown being laid on the same copper plate, and kept at the same heat *only three quarters of an hour*, a permanent and *far more apparent* spectrum was produced, than in the former case; the *whole area* where the half-crown had laid, was covered with a whitish cloud, and the impression dimly sketched. 3. By selecting a half-penny *very much* tarnished, and letting it remain five hours on a bright copper plate, heated to 160° or so, and subsequently for thirty-six hours in the cool, a *permanent* spectrum was produced, in which all the *lettering* of the coin was *beautifully* visible; yet here was copper on copper. But as I found this impression to go off completely at a heat far below what the impression did, at experiment 5, below, the general principle, that silver gives a *stronger impression*, remains. 4. A *well polished* new sovereign and a *tarnished* sixpence being laid on a bright silver plate for four hours, and kept at 160°, the sovereign had left no spectrum, but the sixpence had left a *permanent* one, in which almost all the lettering appeared, so plainly was it visible. 5. A *perfectly* polished half-crown was laid on a pretty well polished sixpence, and a *purposely* tarnished one on a purposely tarnished sixpence, and put on the same plate with the half-penny (exp. 3, above), heated five hours and left thirty-six hours afterwards. The lettering, &c. of each sixpence was visible, but *far* more of the most tarnished; and also this was the case with that of the most tarnished half-crown, as regarded its spectrum. That of the polished was scarcely visible. But the lettering of neither half-crown was visible, though they had remained so long and been heated. This experiment also shows how much the effect is strengthened by *actual contact*. A similar experiment was made in the closed deal box (mentioned in Section 5). The copper plate was laid upon a *polished* and boiled fourpenny piece, and this on a half-crown similarly prepared; after ninety-six hours, no spectrum whatever of the half-crown was visible, by breathing or otherwise, but the fourpenny piece, in actual contact, had left the usual spectrum. The plate had remained *perfectly* polished. All these experiments show that the dissimilarity of metals is not of such importance as has been conceived: they show the difference wanted to produce the effect is a difference in brightness or oxidation, *i. e.* as far as a *permanent* and good impression, *showing the lettering, &c.* is concerned; for I find when left on the plate half an hour or so, tarnished or polished metals give equally good spectra. But in this case the spectrum is only made apparent by breathing, and of course shows *nothing* of the lettering, &c. However, even in this case, the spectrum of the tarnished sovereign disappeared less soon by breathing on it than did that of

the polished one; so in reality the spectrum of the former may be said to have been the most perfect.

The same remark applies to a glass plate (see Section 6, as regards glass, &c.)

9. *Which metal receives images fastest, copper or silver?*—My experiments lead me to say copper, whether heat be applied or not. When the same degree of heat was applied, I found a sovereign produced a good *permanent* spectrum (impression) on a bright copper plate, although only an evanescent one (one seen only when the plate is breathed on) was produced on an equally well polished silver plate, placed at the same time at the same heat. When heat was not applied I found the copper received an *evanescent* spectrum first.

10. *As regards the effect of interposed substances.*—As every substance tried left a spectrum, I did not much expect that the influence would permeate any lamina, even of the thinnest description. Accordingly, when a sovereign or shilling was left twenty-four or forty-eight hours on a piece of stiff, though very thin, paper, it gave no spectrum, but the mark of the paper was alone visible. The experiment was repeated, half the coin resting on the copper plate, and half on the paper: and although it remained a fortnight in this position, the half only *in contact* with the plate was visible by breathing on the paper, leaving *its own* spectral image just as if no coin had rested on it at all.

The same experiment was repeated with the thinnest possible layers of talc, gum, cork, and whalebone, glass, plane and concave,* with the same result. Each substance left its spectrum, the part where the coin rested on such layer not being at all distinguishable. The spectral image of the square piece of talc was perfect to the minutest outline, and left its straight mark under the sixpence equally well as at other points. These experiments render it clear, that the effect is not due to latent light, for otherwise how could it happen that a coin does not leave a spectral image when left on *transparent* substances, glass, or talc, *even a fortnight?* They also show it does not depend on heat (at least alone), for a heat of 160° soon passed through thin glass and talc, and I found it impossible to keep my finger on glass or talc so placed. Yet we have seen above that even gold left two hours on talc so heated left no spectrum, permanent or temporary. So great is the effect of interposed substances, that even a *slight tarnish* on the metal exerts a very obvious effect.† One shilling was left twenty-four hours on a polished part of the plate, and another on a part of the same slightly tarnished (but yet sufficiently bright to see oneself perfectly). A very slight image only was left in the latter case, that entirely disappeared when breathed on twice, while that on the polished part of the plate remained, after being breathed on twelve or fourteen times.

* With the glass the experiment was only continued forty-eight hours; with the paper, talc, and cork, a fortnight, silver coin being used; with the whalebone and gum, ten days, gold coin being used.

† One spectrum, however, may be made on another; thus, after talc had remained eight hours on heated copper plate, and left a permanent spectrum, a sovereign put on this an hour left a permanent spectrum.

A sovereign left twenty-four hours or above, tarnished, gave scarcely a perceptible spectrum, and a sixpence, none at all. On such a surface, a sovereign was left on two different occasions, under a penny, for three hours, at a heat of 160°, and barely left a permanent spectrum of its *outer* margin; while on a well polished surface, at same heat, the outline of the impression also would have been left as a permanent spectrum in an hour or two.

11. *Mass.*—Mr. Hunt considers, that mass exercises an influence, and increases the effect. In my experiments, however, I could not detect this. A farthing on a copper plate gave as good a spectrum as a penny, and when heated to 160°, the farthing gave far the best, though the penny had a halfpenny laid on it. A fourpenny piece, too, gave as good a spectrum as a half-crown, pressed by another above it, in the same time, the contact being equally good in each case. *The contact in these cases was made as equal as possible with the copper plate.*

12. *Does the thinness of the plate exert an influence?*—A farthing (in two experiments) pressed by twelve or fourteen pounds weight, on a polished piece of platinum foil, in thirty hours, left no spectrum at all; neither did it on a fourpenny piece, or a sovereign, or half-sovereign, when kept three or four hours at 160° under the same weight. I found a spectrum could be made on nearly equally thin zinc plates, (zinc *foil)* by leaving a sixpence on it an hour or two. Zinc not being elastic, allows the pressure to be equal. The particular chemical nature of platinum has, however, much to do with this effect; for I found that when a fourpenny piece, or another small brass metal object, was left on a highly polished lamina of steel—heated to 160° or not—a spectrum was scarcely made. That elasticity and consequent *imperfect contact*, is not the sole cause of the incapacity of thin lamina of platinum and steel, for receiving spectral images, was to me rendered *probable* by observing that coins, placed on a thick copper plate, seldom were in *perfectly* close contact, yet gave good spectra. In order to come to a more definite conclusion on this point, I got a lamina of bright copper, even thinner, and as elastic as the platinum lamina, above mentioned. Gold or silver coins left twenty-four hours on this, gave a spectrum scarcely visible; but on leaving a half-sovereign for two or three hours on it, exposed to heat of 160°, as above, and pressed down by exactly the same weight, the half-sovereign left a *permanent* spectrum very well marked indeed.

The result of this experiment obviously shows, that although thinness and elasticity may have some little effect, the principal cause for the formation of the spectrum is the peculiar *chemical nature* of the metal, and *that a spectrum cannot be produced on a non-oxidable metal, such as platinum.* Bright silver and copper plates are well known to *tarnish* by exposure to the atmosphere, (the former, perhaps, rather by forming a sulphuret, than an oxide,) but no matter how. I have also found that spectra could be formed on tin and zinc plates, both of which, of course, are oxidable. So on copper coated with mercury, the mercury in such case, no doubt, readily tarnishing: (see Sec. 7. Polished surfaces not receiving spectra). Having decided

that the effect in question is due neither to light nor heat, to what cause, it may be asked, is it to be ascribed?

Conclusions.—1stly. As *brightness* of the plate is indispensable, and with brightness must exist an *increased tendency* to tarnish, or enter into chemical combination. 2ndly. As the plate must be of an oxidable metal, and judging from the experiments with silver and copper, the more oxidable the better. 3rdly. As the more perfectly the coins are cleaned and dried,* the less the effect, and as a dry perspiration (so to call it) must exist in a greater or less degree on all coins, since they pass through so many hands, and as perspiration is slightly acid. 4thly. As even with *clean* coins the effect† by *actual contact* must be admitted, but still is greater when there is a difference in the nature‡ of the metal; and 5thly. As when the metals are not in contact (being removed only the one-twentieth of an inch apart), no action or spectrum is evident, if the free circulation of air, and the connexion with dust be prevented—taking all these and minor considerations into account, we come to the conclusion that the effect in question is dependent on *chemico-mechanical* action, or what Berzelius has called *catalytic* action. No doubt it may be urged against this view, that the action takes place when the coins and plate are both heated, and hence quite dry. But this is no solid objection, for the adage "Corpora non agunt nisi sint soluta," is not true, as hundreds of examples in chemistry show. The very fact of heat itself increasing the effect, is all in favor of a chemico-mechanical view; for heat increases the tendency of copper to oxygenation, and tends also to volatilize any feeble acid matter on the coins. But again, if it be said the spectrum rubs off, even *when permanent and clearly defined* (as we have shown), *and leaves a polished surface under it*,—this we admit; but still this surface has suffered an *almost imperceptible degree* of oxygenation; for so slowly does this effect take place, that it is only visible when much advanced, as will be evident to any person who watches the gradual tarnishing of copper plates. Möser's discovery shows that *very slight* chemical action is often going on, *which has been previously overlooked.*

The chief difficulty that occurs to the above view, is that the effect takes place, to a slight extent, on glass; but in all my numerous experiments I have found that the effect is much *less* on glass, than on well polished copper; for in no case has a *permanent* spectrum been made on glass, even by the longest contact.‖ It will also be remembered that I found no effect whatever produced on talc. Now, the talc scratches easily, glass, of course, does not; but talc is probably less soluble in acids than glass; at least in my trials it did not seem

* Moisture much increases the effect. Thus, when one surface of a shilling was rubbed over with ink, and such surface put on the copper plate, and heated to 150°, a mark *much* more difficult to be effaced was left than when this degree of heat was applied without moisture.

† This is equally true, as will be remembered, with regard to glass plates.

‡ The *general* result of all the above experiments show this; and, of course, an alteration of affinity from contact, is far more probable when metals are different than when the same: though if one be dirty, this makes it approach the nature of a different metal.

‖ A permanent spectrum has been proved (see experiments) to be but a higher degree of an evanescent one.

at all acted on either by nitric, muriatic, or sulphuric. To be sure, you *perceive* no effect of these on glass, but it does not seem impossible but that some *very* slight effect takes place, and that the alkali of the glass is *very* feebly acted on, as glass is a *compound* body. *Contact*, at all events, may be presumed to have an influence on the affinities of one of its elements, whether there be even the *slightest* degree of decomposition or not. Now, this influence is the catalytic influence; for it has been shown above, that without actual contact, *and when all dust is kept off*, neither silver nor copper, even at the one-twentieth of an inch from the glass plate, produces any effect, though kept there ninety-six hours. (See Sec. 4, of heat generally, end.) In consequence of this slight alteration in affinity, the parts of glass which have been in contact some time with coins or other substances, condense the breath differently from those parts which have not: hence the spectrum.

The effect of glass, *supposing it not susceptible of a gradual change by the action of air similar to oxidation*, is rather in favor of the spectrum depending on a mechanical than a chemical action. I have, in consequence, ascribed the effect to a mechanico-chemical action, or a *catalytic* action, meaning thereby an action so slightly chemical, as, in the present state of the science, to be scarcely appreciable.* The attraction of glass and oxidable metallic plates for *dust*, &c., is very great; and is, perhaps, dependent on the same cause as their attraction for oxygen. Whether or not, I feel pretty well convinced, after a laborious investigation of the discovery in question, that it is not of that wonderful character that Möser and others have supposed; nor calculated to alter our ideas of vision, or of the nature of light. On the contrary, I think with Fizeau (a short notice only of whose memoir I have seen), that no effect *of any consequence* is produced *where organic matters are carefully removed by boiling water and polishing;* for such is perhaps the philosopher's opinion just named, and in as far as our opinions agree, he has the priority. Begun by a purely catalytic action, it is only continued and developed in any *marvellous* degree, when those circumstances are present that permit it to assume a more strictly chemical character.

Lond. Athenæum.

Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.

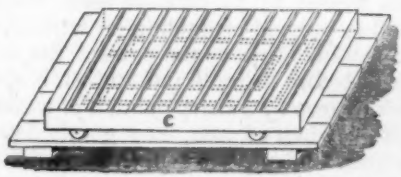
(Continued from Page 62.)

Process of Moulding in Green Sand.—Take, for example, the front of a register grate, which is a familiar instance of light flat moulding. Its construction is that of two jambs joined at the top by a cross piece. On the back, or inner surface, it is quite flat, and is ordinarily ornamented on the face with raised figures of flowers, &c. A box is selected that will receive the pattern, and have a few inches to spare, that the pattern may be completely surrounded with sand.

* In coming to this conclusion, I have not forgotten another difficulty, viz., why a well *polished* and boiled copper coin produces a spectrum on copper plate. The effect, even when continued an hour or two at a heat of 160°, is *very* slight, and I found it to disappear entirely by twice breathing on the plate. *Contact* then, of the same metal SLIGHTLY modifies chemical properties; such, on the present view, is the inference to be drawn from this fact.

The pattern is then laid down either on the surface of a bed of sand, prepared in the upper box, which is lying inverted on the ground, or on a flat board of sufficient size to support it at all parts. In either case the pattern is laid down on its back; there is next thrown over this a layer of fine sand of an inch deep, constituting the facing of the moulding. It is passed through a sieve to detain the coarser parts. Then, upon the board or upper box, which we shall call A, the drag-box, B, is placed in its proper position in respect to the pattern. The annexed figure shows how things now stand.

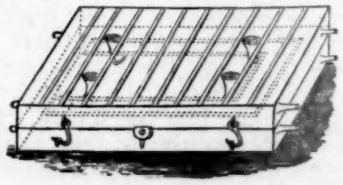
It is necessary to spread the facing of sand before laying down the box, as its ribs prevent the equal distribution of the sand over the pattern. Then a larger quantity of sand is passed through a riddle which saves the small stones and other refuse in the sand.



An additional quantity of the common sand is thrown in by a shovel, and the whole is now rammed down by the flat rammer as equally as possible. This is facilitated by a considerable depth of sand having been laid on, as inequalities in the force of ramming are diminished at the surface of the pattern. The box is again filled up with sand and rammed all over with the round-faced instrument. When the sand is properly set, and squared flush at the surface with the box, B, the whole is turned over, (avoiding sudden shocks of any kind, which tend to loosen the sand) and well bedded on the ground with the box B undermost. The box A, or the board, as it may happen to be used, is lifted off, and the temporary bed of sand in the box A is destroyed. The upper surfaces of the sand in the box B, and of the pattern imbedded in it, are cleaned and smoothed by the trowel, so that the surface of the sand is made flush with that of the pattern all round, and also meets the edges of the box. This forms the *parting*, or place of separation of the sand in the two boxes; and that they may afterwards separate properly, dry sea sand is sprinkled over the parting surface, and has the effect of preventing the adhesion of the sand to what is afterwards superimposed, by entering and drying its pores. The box A is now laid on the other, guided by the pins, and both are fastened together by the hooks. In bringing them together their meeting surfaces ought to be cleared of sand so as to make them bear freely and steadily. Preparations are now made for the construction of the *gates*, or passages, for the iron from the external surface into the mould. In the moulding of a register-grate front there are usually four gates constructed, into which the iron is poured simultaneously. The necessity for having so many openings for the iron must be obvious, on considering that iron rapidly solidifies

as it cools from a melting temperature, and, of course, *sets* in the form of the place it occupies.

To provide for the gates to the moulding, four taper pins of wood are struck in the sand of the lower box at a short distance from the pattern, projecting upward between the ribs of the upper box. Sand is, as before, thrown into this box, covering the flat side of the pattern, and is rammed between the ribs until the box is filled flush with itself. The pins are now withdrawn, and the holes formed by them are widened at the top into bell-mouths to receive the iron the more readily, and are well smoothed there to prevent the metal from carrying in with it any loose sand. The upper box is now taken off with care, to preserve the impression of the upper side of the pattern; and the edges of the moulding in the box B, in contact with the pattern, are wetted with a swab to make the sand, at these corners, the firmer, and to prevent crumbling on withdrawing the pattern. Still farther to facilitate this, as the pattern fits closely in its bed, it must be loosened before being drawn, which is simply effected by taking hold of the pattern by a sharp point, if of wood, or by studs, which are riveted into it when of iron, and gently tapping them laterally and downwards. The pattern is next drawn slowly out of the sand, and it often occurs that the moulding is broken at one or two places, in spite of these precautions, and especially if there be much carved or ornamental work on the pattern. The moulder has, therefore, in the first place, to repair the damages by adjusting disjointed parts, and making up fractures by the addition of sand. All the more prominent and most exposed parts of the moulding, as the extremities of the ornaments, are treated with a touch of the swab, which must be lightly applied so as not to spoil their sharpness. This process, indeed, with that of applying the blackening, now to be described, are the most difficult parts of the art of the flat-moulder. The blackening has now to be applied, and it must, by some means, be pressed down upon the mould at every part, and made to adhere to its surface. To effect this, pease-meal is used—it is first dusted thinly over the surface of the mould. It rapidly absorbs the damp of the surface sand, and is converted into a pasty matter. The blackening is next dusted over the newly formed paste, and over all, the pattern is placed in its position and pressed down. Thus the blackening is made as smooth as the pattern, and is at the same time well held down to the sand. Channels are now scooped out of the surface of the sand, joining the gate-holes to the moulding; and if the pattern be thin, each channel is widened as it joins the mould to afford a sufficient inlet for the iron. They are slightly swabbed round the mouth to confirm the edges against the abrasive action of the iron.



Having finished the moulding, and got it in order for the reception of the iron, the upper box is finally put on the under one in its place, and fastened down upon it.

All is now ready for the pouring of the iron. In the adjoining figure of the boxes in this condition, the moulding is represented within, and the gates leading to it from the surface.

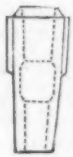
There are several points in the practice of green-sand moulding generally, to which great attention must be paid. In the preceding account, we alluded to the necessity of the sand being rammed as uniformly as possible. Now, it may be too closely rammed altogether, so as to impair its capability of conducting away the confined air, and the gases generated by the heat. There must be a degree of ramming applied proportioned to the heaviness of the casting. If the sand be too closely rammed, the current of iron flowing over the moulding, is agitated by the air not being allowed to pass freely off. In consequence it breaks up the sand and heaves it to the surface, and it is easy to see that this produces excrescences on one side of the casting, while corresponding deficiencies exist, from the same cause, on the other side. If, again, the sand be too loosely rammed, the iron by its weight presses it outward off the moulding, which renders the surface uneven, and swells the casting. Moreover, a certain degree of humidity in the sand is necessary for the goodness of the casting. When the sand is deficient in moisture, the iron is apt to penetrate its pores on the under surface, and so detach the particles of sand there, producing an effect similar to that occassioned by over ramming. On the contrary, if there be an excess of dampness in the sand, the iron, by the sudden formation of aqueous vapor, is frequently repelled altogether, and ejected at the gate like shot. Should this not take place, though the iron may make its way through the mould, the bubbles of vapor form cavities in the casting towards the under side principally, as this side bears all the *run* of the iron passing over it, and is thus more severely tried than the upper side, the iron simply rising to that side, and is there at rest. Excess of dampness, and of over-ramming, are thus nearly alike in their effects, and are the more dangerous extremes. In cases of very large castings, if the air, expanded by the heat, and the other gases generated, do not find a ready vent, they burst through every resistance with explosive energy.

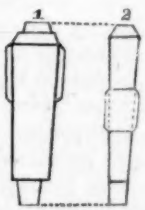
The quantity of blackening to be applied must also be a particular quantity. In noticing, in a former part of this paper, the nature of blackening, and the manner in which it is operated upon by the iron, reference was made to the continued evolution of gas by combustion. If then, by the action of the iron upon the blackening in the mould, too much gas be formed, it collects in globules, and forms corresponding indents in the casting. The skill of the green-sand moulder consists in so laying on the blackening as to produce equilibrium between the antagonistic forces of the iron advancing, and the resistance of the gas produced. After having been pressed down by the pattern, the loose blackening left is rubbed off and blown away. When this is not attended to, the blackening is raised in layers from the surface by the iron, and deposited in other positions, giving the casting, when cool, a rough, clouded appearance. In forming the surface of the blackening upon ornamental moulding, by pressing down the pattern upon it, care must be taken that the pattern be perfectly dried before

being laid over the blackening; for if at all damp, this will adhere to it, and take the pease-meal with it, and so destroy the moulding. And even though it be quite dry at first, yet it may, by lying too long in the sand, contract damp, and so spoil the mould. Swabbing is avoided when not essentially necessary, as the formation of vapor, by the contact of the iron with the water, is, as before noticed, apt to agitate the current, and make the flow irregular. The object of forming the gate to one side of the moulding, is to check the violence of the iron in motion, and to introduce it with regularity. Were the gate formed directly over the moulding, any delicate ornamental work below would be worn off by the continued action of the iron, though certainly it may be so placed, if the moulding at that part be plain. We noticed the necessity of a number of gates to the moulding. The number of these varies with the extent of the surface of mouldings in general, and also according to their thickness. A comparatively deep moulding might be well filled by only one gate, while another of just the same horizontal surface, but shallower, would require two or more gates. In short, there must be as many gates as are requisite to ensure the metal's having thoroughly filled the mould while it is yet liquid. The iron, should, therefore, be run in as quickly as possible to fill the mould completely, and this is especially to be attended to in cases of light-flat, and hollow moulding, as in these the extent of cooling surface is great, compared with the depth or thickness of the iron.*

Before dismissing the subject of light-flat moulding, one other elegant example may be described, introducing the use of three boxes for a moulding. The instance referred to is the moulding of the cast iron bushes, which are fixed in the naves of the wheels of wagons and other vehicles, to sustain the wear of the axle.

The annexed figure is a sketch of an ordinary bush for cart wheels. The dotted lines show the form of the interior, which is a tapered hole. At the middle of the length, as shown, a chamber is formed in the bush, so as to surround the axle —its object is to contain the grease for lubrication. These bushes are always cast in pairs, and the cores for them are cast iron pins, having the form of the axles for which they are intended. These pins, which serve for many successive castings, are turned and polished in the lathe, for the purpose of communicating a smooth surface to the interior of the bushes, by which the expense is avoided of boring them out which would be necessary, were sand cores employed.





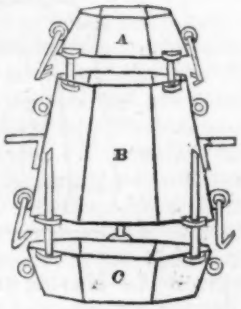
The pattern of the bush is solid, and has, in addition, a core print on each end to steady the core. This is shown by fig. 1, annexed. Fig. 2, shows the core extended at the ends in correspondence with the prints. Round the middle of its length a

* Mr. Neill's patent tiles for roofs afford a remarkable example of the extreme thinness of casting practicable. These tiles are each 18 inches by 6 inches, and weigh 28 lbs. per square yard, which gives one twenty-fourth of an inch for their thickness. Small as they are, they require two gates, on account of their extreme thinness.

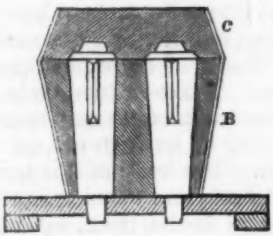
thickness of sand is rapped to form the grease-chamber in the bush. This part is made of sand, so as to be separable, and thus allow the core-pin to be driven out of the bush when cast.

The box in which the bushes are cast consists, as already mentioned, of three parts. The length of the middle part is made the same as that of the bushes between the small end and the tops of the feathers. The parts are octagonal in plan, as represented in the annexed figure. A the top, B the middle, C the bottom.

In proceeding to mould the pattern, a flat board is laid down level, with two holes in it at a suitable distance from each other. Upon this board a pair of bush-patterns are set down on their small ends, the points passing through the holes in the board, to keep the pattern steady. The box B, is inverted and laid down over them, and filled with sand, which is rammed about the patterns level with the tops of the feathers on them. The box C, is now fixed on and rammed with sand. The figure annexed is a sectional view of the boxes and their contents at this stage of the process.

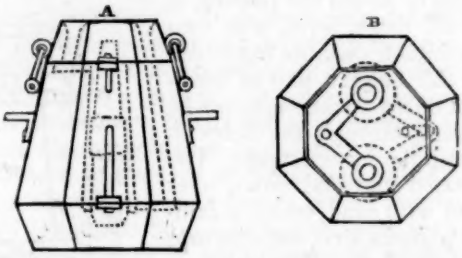


The two boxes together are inverted and set down—the box A, is fixed on the uncovered end of B, and it likewise is rammed flush with sand. Two holes are next pierced downwards in the sand, with the handle of the rammer, one to each side of the patterns. One of them extends just through the box A, the other reaches down to the box C. A and B, together, are lifted off C, and turned over, the patterns, loosened by tapping, are next drawn out. A and B are then separated. Two prepared core-pins are next set, as vertically as possible, into the recesses left by the prints in the sand of the lowest box; on the surface of the sand at each end of the box B, channels are cut joining the gate-holes, made by the rammer, to the two mouldings, in such a manner as that the short gate will be connected with the upper end, and the long gate with the under end of the mouldings. B is lowered over the cores, and fixed to C, being directed by the long guide pins at the side. A is next replaced, guided also by pins, and fixed to B. It must be placed with care, as the upper ends of the cores are at the same time entering the recesses made by the prints. And thus the cores are secured between the boxes A and C.



The moulding, as thus finished, is shown in fig. A, which is an external view of the whole, with the interior arrangement in dotted lines. Fig. B, is a view of the upper and under ends of the middle

box, showing the gate channels. The iron is poured into the long gate, falling against the bottom of it, the force of the iron is broken, and it runs gently into the mouldings, rising within them till they are filled, when it passes into the short-flow gate, as it is termed; from which it issues, carrying off the refuse it may have gathered in its passage. Blackening is not applied to these moulds, as their roughness is of no consequence.

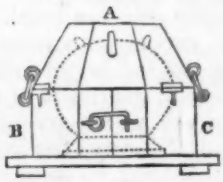


Section II.—Having in the first paper on this peculiar art, given two detailed examples of the mode of moulding and casting light, flat ware, illustrating, generally, the manner of conducting the manufacture of these goods; the practice of hollow moulding falls now to be described, as that branch of moulding naturally precedes in order of description, the heavier species of green-sand moulding.

The distinct objects of hollow moulding are comparatively few in number, and small in dimension; there are moulding boxes for them individually of corresponding shape, generally manageable by one person. Boxes in two, three, or four parts, are employed as the necessities of the case may require. We shall select, for example, the moulding of an Irish pot, of which the annexed is a sketch. The body of it is nearly spherical, drawn in at the neck, and opening towards the brim. It has two ears at the neck, by which it is moved about when in use, and three feet on the bottom. The pattern is an exact model of the pot, being in two halves separating vertically. The patterns of the feet and ears are also loose on the body of the pattern, fitting to it by pins. To form an original pattern, the method usually adopted is that of moulding in loam, which will be understood afterwards, when we come to describe this branch of the art. In the mean time, it is sufficient to state, that the rough cast pattern is chucked in the turning lathe, and turned within and without to the required form and thickness, in doing which, it is facilitated by boring four longitudinal rows of small holes through the pattern at equal distances round it, by which its thickness at any part may always be ascertained. Having been smoothed and polished, the pattern is taken from the chuck, and cut in two equal parts, in which holes are bored at the proper positions for receiving the pins of the ears and feet.

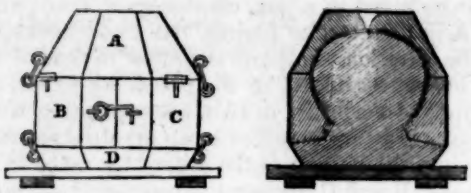
The pattern is moulded in a box, consisting of four parts, named the top, marked A in the ensuing figures, the two cheeks, B, C, and the bottom, D; the division into parts is similar to that of the moulding box for axle bushes described in the preceding paper, supposing the middle part divided vertically in two, corresponding with the cheeks, B, C. The pattern being moulded in an inverted position, the top, A, is made to inclose the bottom of the pot, as far up as its largest diameter; the cheeks, B and C, inclose the remaining portion of the pot, and the bottom, D, serves to close up the mouth of it.

The two cheeks are first of all laid down on a level board and linked together; the pattern is then laid down on its brim within the cheeks, being raised off the board by a slip of wood, of which the thickness is adapted to bring the largest diameter of the pot to the level of the upper edges of the cheeks. The patterns of the ears are attached, and sand is rammed in round the pattern flush with the cheeks, making the parting surface on the centre of the pot. The surface having been sprinkled with parting sand, the top, A, is put on, led into its place by guide pins, and fastened to the cheeks. Sand is again rammed into the level of the mouth of the box, the patterns of the feet and the gate pin being set in their places in the course of the ramming of the sand. The annexed fig. shows the position of things as now described. The whole is next inverted, and the board and slip of wood removed. The surface of the sand round the brim of the pattern is smoothly sloped off to the edge of the box, forming the parting surface, and the bottom, D, is fixed on. It is also filled with sand. The body, or core, of sand filling the interior of the pattern, is pierced in several places with a pricker sent down to the pattern, forming thereby channels of escape for the air expelled by the metal introduced. The whole is finally re-inverted, D lying undermost, and placed on a flat board with a hole in it to allow the escape of the air. The sand outside the pattern is sometimes pricked, though this is but of little importance.



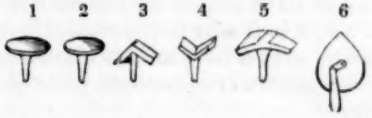
The part A is now separated and lifted off, carrying the feet and the pin with it. The cheeks, B, C, are next separated horizontally, taking the ears with them; and the half patterns are withdrawn from the core. The external and internal moulds, thus exposed, are sleeked up with appropriate tools, and blackening is dusted on them, and also sleeked up. The patterns of the feet and ears, and the gate pin are drawn out, the boxes, B, C, are replaced exactly as before, and the box A, above them, the whole being again bound together. The mouth of the gate is next formed and smoothed. The space occupied by the pattern is now vacant for the metal. This is an external view and section of the box and moulding. In the section are shown the parting surfaces, and the slope of the under one.

All dished utensils are cast with their mouths downwards, and in some cases, the area of the mouth is so small, compared with the



largest diameter, as to render it necessary to bind down the core in the mouldings; for it is very evident that the iron lying so far in below the core, tends, by its upward pressure, to lift the core off from its base. Such a result would, of course, spoil the casting. This binding is requisite in kettle mouldings in particular. It is simply effected by burying an iron rod in the core, having on it a cross at the end to give it a hold of the sand, the outer end being locked to a transverse piece which bears on the edges of the box.

The metal requires to be at a high temperature for hollow moulding; for so quickly does it cool, that the brim of a moderately sized pot *sets* even before the mould is filled. While yet red hot, the casting is taken out of the sand, and the gate piece knocked off. This must be done at a certain stage of the cooling, as when too soon done, the gate does not break clearly off; and when delayed too long, it often carries out a piece of the bottom of the pot with it. With a view so far to provide against this, the pot is made considerably thicker at the centre of the bottom. Flat gates are formed for flat bottomed ware—frying pans, for example. They are wide at the mouth to receive the iron the better, but taper like a wedge, towards the moulding, so as to be easily separated from the casting. By being of considerable extent, flat gates conduct the metal more speedily to the different parts of the mould.



Here are represented the forms of the cast-iron sleekers, employed in the operations of hollow moulding. Nos. 1 and 2, show the convex and concave sleekers for corresponding surfaces. Nos. 3 and 4, are tools with double plane surfaces, at certain angles with each other. Of these there is a variety, having their planes at different angles to suit the various salient and retreating angles that occur in mouldings. No. 5, is a sleeker for the impressions of beads; and No. 6 serves to smooth flat surfaces generally. All these have small studs attached to them which serve for handles.

(To be continued.)

Description of Mr. Clay's New Process for making Wrought Iron direct from the Ore; as practiced at the Shirva Works, Kirkintillock, Scotland. By WILLIAM NEALE CLAY.

In this communication, the author first describes the various stages through which the metal passes, between the reduction of the ore, and its arriving at the state of malleable iron, by the ordinary mode of manufacture; and then he explains the process which he has invented, and introduced practically at the Shirva Works.

By the ordinary system of iron-making, the ores are reduced into the state of carburet of iron, and then, by refining and puddling, the metal is de-carburetted, thus making it into malleable iron by a number of processes, which are recapitulated:—

1st. Calcining the ore.

2nd. Smelting in a furnace, by the aid of blast, either cold or heated, with raw coal, or coke, for fuel, and limestone as a flux.

3rd. Refining the "pig" into "plate" iron.

4th. Puddling, shingling, and rolling, to produce the "rough," "puddled," or No. 1 bars.

5th. Cutting up, piling, and rolling, to produce "merchant," or No. 2 bars.

6th. A repetition of the same process, to make "best," or No. 3 bars.

Seeking to diminish the number of manipulations, by the new process a mixture of dry Ulverstone, or other rich iron ore, (Hæmatite) is ground with about four-tenths of its weight of small coal, so as to pass through a screen of one-eighth of an inch mesh. This mixture is placed in a hopper, fixed over a preparatory bed, or oven, attached to a puddling furnace of the ordinary form. While one charge is being worked and balled, another gradually falls from the hopper, through the crown, upon the preparatory bed, and becomes thoroughly and uniformly heated; the carburetted hydrogen and carbon of the coal, combining with the oxygen of the ore, advances the decomposition of the mineral, while by the combustion of these gases, the puddling furnace is prevented from being injuriously cooled. One charge being withdrawn, another is brought forward, and in about an hour and a half, the iron is balled, and ready for shingling and rolling. The cinder produced, is superior in quality to that which results from the common system; it contains from 50 to 55 per cent. of iron, and is free from phosphoric acid, which frequently exists, and is so injurious, in all the ordinary slags: when re-smelted, it produces as much No. 1 and No. 2 cast-iron, and of as good quality, as the ordinary "black band" ore of Scotland. The cast-iron produced from the slag (amounting to one-third of what was originally contained in the ore), is mixed with the ore and coal in the puddling furnace; and thus, while nearly all the iron is extracted from the ore, as much wrought iron is produced in a given time, and at the same cost of fuel, as by the old system. The first process, producing puddled bars of superior quality, is, consequently, on a par with the fourth stage of

the old system, as it avoids the necessity of the preceding separate manipulations. From the absence of all deleterious mixture, by once piling and re-heating the rough bars, iron is produced, of a quality in every respect equal, and in powers of tension, superior, to that which results from the second piling and reheating in the common mode; it is, therefore, contended that the two processes produce from the hæmatite nearly one-third more iron, of as good a quality as is usually obtained by the six processes of the old system. The iron thus produced bears a high polish, is very uniform in its texture, is ductile and fibrous, having more than an average amount of tensile strength, and at the same time appears to be more dense, as it possesses a peculiar sonorousness, resembling that of a bar of steel when struck. It has also been converted into steel of a good quality.

The paper is illustrated by a drawing of the furnace necessary for the process, and by specimens of the iron and steel produced.

Remarks.—Mr. Clay contended that the ordinary method of making iron was neither so scientific, nor so practically good as there was reason to expect it would have been, when iron formed so considerable an item in the productive industry of the country. His invention was in some degree based upon the old Catalan fire, wherein malleable iron was produced direct from the ore, although by a considerable expenditure of fuel: by his process the ore was also reduced at one operation into the state of malleable iron, by combination with a large portion of carbonaceous matter; and as the deoxidation of the ore could proceed simultaneously in an adjoining preparatory bed, through which the flame of the puddling furnace traversed, there was necessarily a great saving of time, labor, and fuel in the production of the metal, while the quality was at the same time improved. He argued, therefore, that if the system was generally adopted, a large portion of the capital now sunk in the expensive constructions of blast furnaces, blowing engines, &c., would be dispensed with.

Mr. Taylor observed that the process appeared to be only applicable to the rich qualities of iron ore, which were now used in comparatively small quantities, as a mixture with the clay iron stones of the coal fields, from which iron was generally produced in this country. There existed large quantities of hæmatite in Great Britain, equal in quality to that of Nassau, or of the Hartz mountains, from which so much iron was made, for converting into steel. The mines of Ulverstone alone now produce 50,000 tons annually, and at least 25,000 tons more could be shipped from Cornwall; and if a demand existed, there was scarcely a limit to the quantity that could be raised. He apprehended that the iron made by this process could be converted into good steel: this was very desirable, as it would render this country independent of Sweden and Russia, whence nearly all the steel-iron was now imported.

Mr. Heath had examined Mr. Clay's process of iron making, and found that the wrought iron produced from a mixture of Scottish pig-iron, and hæmatite ore, was of a superior quality, bearing severe tests without injury. The iron made by this method, from India pig-iron and specular iron ore (per-oxyde of iron) from Devonshire, which was

identical in quality with the celebrated Elba ore, when converted into cast steel, by a process which he had accidentally discovered, possessed the quality of welding like shear steel, without any of its defects. The method he alluded to, was to combine manganese with the cast steel in the crucible, and when drawn out under the tilt hammer it could be worked and welded to iron, like shear steal: the consequence of this discovery was, that the latter quality of steel was almost abandoned for cutlery, and the former was now generally used, as it did not exhibit the laminated appearance when polished, which shear steel frequently did. The metal was sounder, and fewer wasters were made. All the brown hæmatites contained manganese, and there was little doubt that, by selecting the proper kinds of ore, malleable iron might be made in Great Britain by this process, as good for converting into steel as any of the Swedish iron. There was abundance of specular iron ore on Dartmoor, equal to the Elba ore, and which would (he had little doubt) produce as good iron as that from the Dannemora ore.

Dr. Faraday remarked that the process invented by Mr. Clay was founded on sound chemical principles. It was desirable to abandon the use of limestone as a flux: it was proved that the purest limestones contained phosphates, which, although advantageous in agricultural processes, were detrimental in iron making.

Mr. Fox had tried some specimens of Mr. Clay's iron, and found them to bear severe tests, as well as the best cable bolt iron made in the ordinary manner.

Mr. Clay explained that Mr. Heath's process was not indispensable for converting into steel the iron made by his method; and also that argillaceous iron ores, after calcination, could be treated in his furnace, like the hæmatite ores, but not so advantageously.

Mr. Taylor said that 25,000 tons of steel were converted annually in this country, and of that quantity not more than 2500 tons were made from the best Swedish iron; for the remainder, inferior qualities of iron, such as Russian iron, marked CCND, from the forges of Monsieur Demidoff, were used. All that iron was made with charcoal, and could only be called inferior, when compared with that made from the Dannemora ore. If Mr. Clay's process was successful in treating the hæmatite ores, as had been stated, it was of great importance, as it would emancipate the country from a dependence upon foreign products. He had recently seen in Germany, a process of producing steel by stopping the operation of puddling pig-iron at a certain point, or intermediate state between cast and wrought iron, and hammering the mass at once into bars. The operation was one of much delicacy, and depended entirely upon the skill of the workman.

Mr. Heath believed the manufacture of steel was involved in unnecessary mystery; it was the general opinion that foreign iron was essential to produce good qualities. Iron as now made from coke furnaces, certainly contained too much foreign matter to be used for steel, and it would require more attention to the selection of the materials, before pure iron could be obtained; some of the Low Moor

iron, the good quality of which was universally admitted, had been made into blistered steel, but although the springs made with it appeared perfect, it was said that they did not answer so well as those made with steel from charcoal iron. The Sheffield manufacturers required that steel should possess "nature and body;" the first quality to enable it to be rolled and drawn out without cracking, and the second, that it might receive and retain a fine edge. Steel made from Garnderris iron (South Wales) possessed "nature," but if made into cast-steel, it fled into pieces in working, as it did not possess "body." Steel from German ores appeared to have "body," but wanted "nature." Steel from Indian iron, although difficult to work, stood better than other kinds when once reduced into form; this he attributed to the purity of the magnetic ore from which it was produced; there was not the slightest trace of phosphorus, arsenic, or any deleterious foreign matter. He was convinced that, with a mixture of Indian pig-iron (which could be produced very cheaply) and Devonshire ore, by Mr. Clay's process, iron could be made of excellent quality for converting into steel at such a reduced price, as would render the introduction of Swedish and other foreign iron unnecessary.

Mr. Taylor believed that improvements in the quality of steel, rather than reduction in the price, was the object sought. In the large quantity used in the mines under his direction, the dearest steel was found to be the more economical. He had seen as many as 12 dozen borers used to make one blast hole, and unless the tools kept their points well, the labor of the men was thrown away.

Civ. Eng. & Arch. Journ.

On the Perfect Ventilation of Lamp Burners.

In consequence of the injury sustained by the books in the library at the Athenæum Club, amounting almost to the entire destruction of the bindings; and the complaints of the members of the vitiated state of the air in the rooms, causing headache, oppressive breathing, and other unpleasant sensations; Professor Faraday's attention as a member of the club, was drawn to the subject of ventilating lamp burners in houses; and he was induced to suggest the trial of various plans, for affecting the removal of the products of combustion, produced by sources of artificial light. All substances used for the purpose of illumination, may be represented by oil and coal gas; although tallow and wax are also greatly employed, yet as until they are rendered fluid like oil, they cannot be burnt, they may for all practicable purposes be classed with it. Now, oil and gas both contain carbon and hydrogen, and it is by the combination of these elements with the oxygen of the air, that the light is evolved. The carbon produces carbonic acid, which is deleterious in its nature, and oppressive in its action in closed apartments, and the hydrogen produces water. A pound of oil contains about 0.12 of a pound of hydrogen, 0.78 of carbon, and 0.1 of oxygen; when burnt it produces 1.06 of water, and 2.86 of carbonic acid, and the oxygen it takes from the atmosphere is

equal to that contained in 13.27 cubic feet of air. A pound of London coal gas contains, on an average, 0.3 of hydrogen, and 0.7 of carbon; produces when burnt, 2.7 of water, and 2.56 of carbonic acid gas; consumes 4.26 cubic feet of oxygen, equal to the quantity contained in 19.3 cubical feet of air. So a pint of oil, when burnt, produces a pint and a quarter of water; and a pound of gas produces above 2½ pounds of water; the increase of weight being due to the absorption of oxygen from the atmosphere, one part of hydrogen taking eight by weight of oxygen, to form water. A London Argand gas lamp, in a closed shop window, will produce in four hours, two pints and a half of water, to condense or not, upon the glass or the goods, as it may according to other circumstances happen; also, a pound of oil produces nearly three pounds of carbonic acid, and a pound of gas, two and a half pounds of carbonic acid. Now, carbonic acid is a deadly poison, an atmosphere containing even one-tenth of it, is soon fatal to animal life. The various accidents from lime and brick kilns, from brewers' vats, occasionally from the sinking of wells, as at Cheltenham, and from the choke damp in coal mines, attest the extreme danger contingent upon the presence of this substance. A man breathing in an atmosphere containing 7 or 8 parts of carbonic acid, would suffer, not from any deficiency in oxygen, but from the deleterious action of the carbonic acid. M. Leblanc has recently analyzed carefully the confined air of inhabited places, and concludes, as stated in his *Memoire*, that the proportion of carbonic acid gas in such places, may be regarded as measuring with sufficient exactness, the insalubrity of the air; that in the proportion of one part to a hundred of air, ventilation is indispensable for the prevention of injury to the health; that the proportion of carbonic acid gas had better not exceed a five hundredth part, though it may rise without inconvenience, to a two-hundredth part. If a lighted taper be applied to the top of a lamp chimney, it will be instantly extinguished, or a glass jar held over it will become immediately filled with air, in which a light cannot burn. Also sulphurous and sulphuric acid, are contained in the water which results from the combustion of coal gas, and are products injurious to metals and articles of furniture.

It will now be understood, that the object sought to be obtained in the ventilation of lamp burners, is the entire removal of all the noxious products of combustion. And with this view, at Professor Farraday's suggestion, the gas lights of the chandelier in the library of the Athenæum, were ventilated by pipes dipping into the lamp glasses, and conjoining at a short distance upwards into one central pipe, which carried away all the burnt air out of the room. In this first practical experiment, many things were learned as to the mode of arranging the pipes; the disposal, when the pipes were very long, of the water produced, &c.; but the objects sought for by the ventilation, were at once and perfectly obtained. This principle may be illustrated by a simple experiment, showing the difference between allowing combustion to give its products to the air of a room, and carrying off these products as soon as formed to the exterior; let a short wax candle be placed burning on a plate, a glass jar put over it, and the upper aper-

ture of the jar closed by a globular cork, through which passes a piece of glass tube, about half an inch in diameter, and twelve or fourteen inches long; the tube descending to the top of the candle flame, and being placed just above it. Under these circumstances there will be plenty of air passing into the jar, between it and the plate, and out by the tube, to supply all that is needed for combustion, and keep the glass chamber sweet; the consequence is, that in this position it will go on burning for any length of time, and the jar remain quite clear and bright; but on moving the cork a little, so that the tube shall no longer be over the flame, all these results will change, though the air-way remains exactly as before. The candle will now give the products of its combustion to the general air of the glass chamber, the glass will immediately become dull, from water deposited upon it, the air itself will become worse and worse; the light become dim, and in a few minutes will go out. But if arrested from doing so by the tube being again placed over it, signs of recovering will appear, the light will return to its former brightness, and after a short time, even the dew will disappear from the glass; all in consequence of the proper ventilation of the light. These effects, though striking, may easily be understood by any one who will think of the difference of lighting a fire in the middle of a room, instead of under, or in right juxtaposition to a chimney.

Then came the desire of modifying the system, by removing the ascending flue from its place over the lamp, not from any deficiency in action, but for appearance sake only; and finding that there was sufficient ascension power in the main part of the metal chimney, to allow of a descending draught over the lamp, the tube, in place of going directly upwards, was made to turn short over the edge of the glass, to descend to the area or bracket, to pass along it, and then ascend at the central part of the chandelier, or against the wall if applied to a single light. To this succeeded another form, which is exceedingly beautiful, and appears to be the perfection of lamp ventilation. It is, in fact, a beautiful application of the principle of a descending draught to a lamp burner. The gas light has its glass chimney as usual, but the glass holder is so constructed as to sustain not merely the chimney, but an outer cylinder of glass, larger and taller than the first; the glass holder has an aperture in it, connected by a mouth-piece with a metal tube, which serves as a ventilating flue, and which, after passing horizontally to the centre of the chandelier, there ascends to produce draughts, and carry off the burnt air.

The burnt air and results of combustion, take the course indicated by the arrows, and are entirely carried away by the chimney. Now with a lamp burning in the ordinary way, the products of combustion issue out as a torrent of ærial impurity from above, but if the above arrangement be applied, on closing the top of the outer glass cylinder by a plate of mica, all the soot, water, carbonic acid, sulphurous and sulphuric acid, and a portion of the heat, are entirely carried away by the ærial sewerage, and discharged into a chimney, or the open air, and the air in rooms may thus be kept in the same sweet and whole-

some condition, and fit for the purposes of respiration, as if artificial light were not being used.

Fig. 1.—*a*, is the burner; *b*, the gas pipe leading to the burner; *c*, the glass holder, with an aperture in it opening into the mouth-piece *d*, which is attached to the metal chimney, *i*; *e*, the ordinary glass chimney; *f*, an outer cylinder of glass closed at the top by a plate of mica, *g*, or still better, by two plates of mica, one resting on the top of the glass, and the other one, *h*, dropping a short way into it; they are connected together by a metal screw and nut, which also keeps them a little apart from each other, thus forming a stopper which cannot be shaken off the glass chimney, but is easily lifted on and off by the small metal ring or knob at the top; *i*, is the metallic tube chimney; *k*, a ground globe, which may be applied to the lamp, and which has no opening except the hole at the bottom, where it rests on the glass holder; but any other form, as a lotus glass, or a vase, may be substituted at pleasure.

Fig. 1. Fig 2.

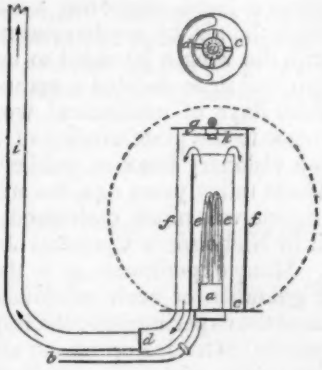


Fig. 2, is a plan of the glass holder, showing the burner, *a*, in the centre, perforated with jets, with openings round it to allow of a free admission of air to the flame, and the aperture *d*, which opens into the mouth-piece, connected with the metal chimney, *i*.

A curious but important result of the inclosed lamp, is the increase of light produced, amounting to from 10 to 20 per cent., according to circumstances, the same quantity of gas being consumed as before. If the current of air through a lamp glass, when the gas is burning in the usual manner, be diminished, the flame rises in height, and the light is increased in amount, but is of a redder color; the combustion in fact is not so intense, because the access of air is retarded; the particles of carbon which give the light, are not so highly ignited, but are more abundant, and are ignited for a *longer time*, thereby causing an increase of light.

The advantages of the above plan are many; it is not in the least objectional in architectural appearance, the ventilation is perfect, the heat given to a room is modified and pleasant, and may be either sustained or diminished at pleasure; the light, for good philosophical reasons, is increased considerably for a given portion of gas, and increased safety from accidents is obtained; as in the event of any leakage from the pipes, or from a gas cock being inadvertently left open, the gas, instead of mixing with the air of the room, and becoming explosive, would be almost inevitably carried off by the metal tubes.

We understand that Prof. Faraday has transferred his right to this invention, to his brother, a gas-fitter, who has secured it by a patent.

Civ. Eng. & Arch. Journ.

Retrospect of the Progress of Aerial Navigation, and Demonstration of the Principles by which it must be governed. By Sir GEORGE CAYLEY, Bart.

Sir,—Within the last six months there has been considerable excitement evinced, respecting a scheme for transporting men and goods through the air, by mechanical means, without the aid of balloons to sustain the weight intended to be thus conveyed. The proposal was announced in so decided a manner, and in such startling terms, that in these days of mechanical wonders, some are disposed to give full credence to the practicability of the undertaking, and others to reject it as a visionary hoax on public credulity.

About thirty years ago, the subject of ærial navigation by mechanical means was much canvassed, and several papers were published on it in Nicholson's Chemical Journal, the Philosophical Magazine, &c. Many experiments, as to the means of support, and the stability and guidance of such machines, were then made on a large scale, some of the experimental vehicles having from three to four hundred feet of canvas extended on masts, and braced by rigging, to give strength and precision of position to their surfaces. These trials proved in the most decided manner, that perfect stability and guidance were effected, and that the means of support, to a certain limited extent, were attainable. For instance, it was proved that a man placing himself in a machine of proper dimensions for his weight at the top of a mountain, say one mile above the level of the plain below, might, in calm weather, with steadiness and security proceed through the air to any place to which he might choose to steer himself, about eight miles in horizontal measure from the point of his departure. Of course, in this case the line of flight must be in a continued descent of one in eight, and gravitation is the only cause of the progress of the machine; the case, being, in some measure, similar to that of a carriage running down hill without horses. If, instead of this machine being allowed to descend in its path by gravity alone, the man had applied his power to propel it, by revolving oblique fliers, or other suitable means of waftage, he might probably have extended the distance from eight to twelve or fifteen miles; but the muscular strength of a man is not sufficient to maintain a horizontal path, unless it be for a very short time.*

To render ærial navigation by mechanical means alone, efficient, some first mover is required, which combines great force with little weight. The steam engine, in any of those permanent forms, calculated for real service, together with the water and fuel it requires, would probably be found inconveniently heavy for the purpose, if not

* Many years ago, Mr. Degen, who was a prisoner at Vienna, by means of large surfaces formed like umbrellas, succeeded in elevating himself fifty feet, as measured by a cord which was attached to his machine by the goaler for safe custody, but at the expense of the total exhaustion of his muscular strength in a couple of minutes. A man, when running up stairs for a few seconds, is exerting the ordinary power of two horses—being twelve times greater than the power he can use with permanent effect.

absolutely inefficient,* and I believe it was this consideration, coupled with the serious expense of ascertaining the fact practically, which, at the date I have alluded to, operated as a check to future inquiry on the subject. When, however, a lighter first mover should be invented, every other part of the apparatus was in readiness to meet the discovery, and realize the scheme.

As the principles of ærial navigation, by mechanical means, are few and simple, a recapitulation of them at the present moment may not be unacceptable to your readers, and may enable them to judge more correctly of the project I have alluded to, when more distinctly presented to the public.

Fig. 1.

The leading principle of ærial navigation, is that of the inclined plane. Suppose A B, fig. 1. to represent an inclined plane, rising one foot in ten; it is well known that if the ball F, weighs 100 lbs., a force of 10 lbs., applied horizontally, would sustain it from rolling back. Conceive the same line A B, to represent, also, the section of a large surface, like the sail of a ship, and that C G represents a cord by which it is sustained from being driven back by a horizontal wind blowing in the adverse direction. If the sail contains 100 square feet of surface, and the wind has sufficient power to press with one pound to the foot, 100 pounds weight will be supported, and the tension on the cord will be only 10 lbs. It is the same thing whether the wind thus blows against the sail, or the sail be driven, with equal velocity, horizontally in calm air; the 10 lbs. propelling power, will still sustain the 100 lbs. in the air. It is difficult to ascertain the precise angle used in the wings of birds; but one in ten certainly exceeds that of most birds, and probably one in sixteen is nearer the truth.

Fig. 2.

The stability of these machines is maintained laterally, by making

* The water used in the high pressure tubular boilers, amounts to about 70 pounds per horse power per hour, the fuel about 10, so that the food of the steam horse is about 80 per hour. The engine itself, if of the lightest efficient structure, may weigh about 150 lbs. to the horse power. If the steam were condensed again, by exposure within extended surfaces to the cooling influences of the current of air, no larger supply of water would be required; but such extended surfaces are inconvenient, and add greatly to the weight.

the surface in its cross section, as represented in fig. 2. By this means, the side that comes down in any heel of the vehicle, meets a *greater* resistance, whereas, that which has necessarily gone up, meets with *less*, and this contrary action, operating on a large extent of leverage from the centre, immediately restores the proper position. The distance of the centre of gravity G, below the centre of support, also tends greatly to increase this power, and mainly contributes to the stability of the machine in the line of its path. This, however, is also aided by the adaptation of a horizontal rudder, like the fan tail of birds, used for the purpose.

The side guidance is perfectly effected by a rudder in a vertical plane, as in the case of ships, and elevation and descent are produced, in ordinary cases, by having the command of the horizontal rudder already noticed; but when progressive motion is not required, and the ascent or descent is to be made perpendicularly, then the effect is produced by the power being applied to extensive oblique vanes, or fliers, which, when not employed in this way, are so made as to become flat, and thus form the surfaces already described. The progressive impulse is most readily obtained by smaller oblique vanes, like the screw propellers in boats, worked by the power of whatever engine is employed; or the oblique wing waftage, as is used by birds, may be employed.

The real question rests now, as it did before, on the possibility of providing a sufficient power with the requisite lightness. I have tried many different engines as first movers, expressly for this purpose. Gunpowder is too dangerous, but would, at considerable expense, effect the purpose; but who would take the double risk of breaking their necks, or being blown to atoms? Sir Humphrey Davy's plan of using solid carbonic acid, when again expanded by heat, proved a failure in the hands of our most ingenious engineer, Sir M. Isambard Brunel.

As all these processes require nearly the same quantity of caloric to generate the same degree of power, I have for some time turned my own attention to the use, as a power, of common atmospheric air expanded by heat, and with considerable success. A five-horse engine of this sort was shown at work to Mr. Babbage, Mr. Rennie, and many other persons capable of testing its efficiency, about three years ago. The engine was only an experimental one, and had some defects, but each horse power was steadily obtained by the combustion of about 6½ pounds of coke per hour, and this was the whole consumption of the engine, no water being required. Another engine of this kind, calculated to avoid the defects of the former one, is now constructing, and may possibly come in aid of balloon navigation—for which it was chiefly designed—or of the present project, if no better means be at hand.

London, March 25. Mechanics' Magazine.

Hot-Blast Case—NEILSON'S *Patent.*

After a long trial of ten days, unprecedented, we believe, in the annals of the Jury Court of Scotland, a verdict was returned in favor of the pursuers, at six o'clock on Saturday evening, the particulars of which will be found subjoined. The following is a copy of the issues:—

Issues in the Cause in which James Beaumont Neilson, of Glasgow, engineer, Charles M'Intosh, formerly of Crossbasket, now of Campsie, John Wilson, formerly manager of the Clyde Iron Works, now of Dundyvan, for themselves; and James Oswald, of Shieldeall, now one of the members of Parliament for the city of Glasgow, James Dunlop, jr., merchant in London, brother-german of Colin Dunlop, after designed, Andrew Bannatyne, writer in Glasgow, Charles M'Intosh, aforesaid, James Dunlop, formerly of Fludyer street, Westminster, now residing at Clyde Iron Works, nephew of the said Colin Dunlop, and John Wilson, aforesaid, as trust-disponees of Colin Dunlop, formerly of Clyde Iron Works, thereafter of Tolcross, now deceased, conform to his trust-disposition, and deed of settlement in their favor, dated the 29th day of January, in the year 1834, and two codicils thereto, dated respectively the 29th day of June, 1836, and 29th day of May, 1837, which trust-disposition and codicils are all recorded in the Sheriff Court books of Lanarkshire, the 27th day of September, 1837, as also executors *nominate* of the said Colin Dunlop, conform to confirmed testament in their favor, expede before the Commissary of the Commissariot of Lanarkshire, of date the 18th day of April, 1838—are *pursuers*;—and

Messrs. William Baird, Alexander Baird, James Baird, Douglas Baird, and George Baird, carrying on business in partnership at Gartsherry Iron Works, in the parish of Old Monkland, under the firm of William Baird and Company—are *defenders.*

It being admitted that, on the 1st day of October, 1828, the pursuer, James Beaumont Neilson, obtained letters patent under the Great Seal used in Scotland, in place of the Great Seal thereof, and duly enrolled a specification, in terms of the proviso contained in the said letters-patent, being Nos. 30 and 31 of process;

It being also admitted that the pursuers, other than the said James Beaumont Neilson, have acquired, by assignment from him, a joint interest in the said patent;

Whether, in the course of the year 1840, and between the 27th day of March, and the 7th day of May, in the said year, and during the currency of the said letters-patent, the defenders did, in, or at their iron works at Gartsherry, by themselves, or others, wrongfully, and in contravention of the privileges conferred by the said letters-patent, use machinery, or apparatus, substantially the same with the machinery, or apparatus, described in the said specification, and to the effect set forth in the said letters-patent and specification, to the loss, injury, and damage of the pursuers?

Or,—1. Whether the invention, as described in the said letters-

patent and specification, is not the original invention of the pursuer, the said James Beaumont Neilson?

2. Whether the description contained in the said specification is not such as to enable workmen, of ordinary skill, to make machinery, or apparatus, capable of producing the effect set forth in the said letters-patent and specification?

3. Whether machinery or apparatus, constructed according to the description in the said letters-patent and specification, is not practically useful for the purposes set forth in the said letters-patent?

July 5, 1842. (Signed) D. Boyle, I. P. D.

The damages are laid as under—

Profits claimed, as at the date of action,	£10,000
Other damages, as at the same date,	10,000
Total damages laid,	£20,000

Edinburgh, March 4, 1843.

The Lords having heard counsel on the respective motions for the parties, ordain the minutes for the pursuers, dated 4th July, and 16th November, both last, Nos. 46 and 52 of process, to be engrossed on the issue in this case as relative thereto.

(Signed) D. Boyle, I. P. D.

July 4, 1842.—Rutherfurd, for the pursuers, stated to the court, he agreed that, under the first issue, it shall be competent to the defenders to try the issue of public use.

(Signed) And. Rutherfurd.

Nov. 16, 1842.—Rutherfurd, for the pursuers, agreed that it should be competent for the defenders, in the trial of the issues, as adjusted in this case, to state any objection, in point of law, to the validity of the patent, and relative specification, founded on the nature of the claim and statement there made on the part of the patentee, and that the court should decide the same, by way of direction, in the course of the trial. (Signed) And. Rutherfurd.

The case for the pursuers was opened before the Lord President, and a special jury, in the First Division of the Court of Sessions, on Wednesday, the 10th current.

The Lord Justice General and a special jury commenced, on Wednesday, the 10th of May, to try the above issues in this cause, which may be described as the most important of modern times in this country—whether we consider the vast interests at stake, or the great field of inquiry necessarily comprehended in testing the rights of the respective parties. In the words of the Lord Justice General, in addressing the jury, it was "an unparalleled trial—a trial which has embraced a more expensive body of evidence on both sides, and has occupied more of your attention, than any cause with which I am at all acquainted in this court." This trial occupied ten days, commencing, as we have stated, on Wednesday, May 10, and not terminating until Saturday, the 20th. The question regarded the validity of the patent obtained by Mr. Neilson, in October, 1828, "for the improved application of air, to produce heat in fires, forges, and furnaces, where

bellows and other blowing apparatus are required." In short, Mr. Neilson proposed that the blast should be heated in its passage from the blowing apparatus to the furnace, and delivered hot, instead of cold, as formerly practiced. This was to be accomplished by placing one or more vessels, or air receptacles, between the blowing apparatus and the furnace, and heating those vessels externally in a considerable temperature. "It is better," says the patentee, in his specification, "that the temperature be kept to a red heat, or nearly so; but such a temperature is not absolutely necessary to produce a beneficial effect." When this invention was first made public, it was received with general distrust, and even ridicule; the prevailing, indeed, universal, opinion in the scientific world, and among the iron-masters, both in this country and abroad, having been, that the blast could not be too cold when it entered the furnace. This opinion was so far supported by the practical experience of the time, it having been remarked that the iron smelted better in winter than in summer. These prejudices were, however, dispelled as soon as Mr. Neilson's invention was seen in operation, and producing such prodigious results in the production of iron. Such was the power of hot-blast in the fusion of the materials in the furnace, that the product was doubled—*i. e.* a furnace produced as much in twelve hours with the hot-blast, as it had done in twenty-six hours with the cold. Talking generally, it was also found that this beneficial result was accomplished with one-half less fuel, and one-third less flux, or limestone. As regards Scotland, the great advantages of this invention were manifested in a remarkable degree. In 1828, or before the patent, the total quantity of iron produced in Scotland in one year, was about 60,000 tons; in 1840, the total quantity had risen to about 300,000 tons, being five times the product of 1828. This vast advance was mainly, if not exclusively, attributable to the hot-blast, which had entirely superseded the cold—not a single furnace in Scotland being worked, in 1840, or at the present time, by the cold-blast, with the exception of one at the Carron Works, and which is for their own exclusive use, the pig-iron produced thereby not entering the market. Another important illustration of the advantages of Mr. Neilson's invention, was its effect on the English iron market. In 1830, the total imported iron at Liverpool was 8980 tons, of which there was from Clyde, or Scotland, 3180 tons; in 1841, the total import at the same port was 37,304 tons, of which from Clyde, 30,899; in 1830, the total import of iron at Runcorn, (the other great emporium in England, of the iron trade,) was 3974 tons, of which from Clyde, there were only 11 tons; in 1841, the total import from Runcorn, was 18,161 tons, of which from Clyde, or Scotland, there were 14,306 tons—and every ton of which was, of course, manufactured by the hot-blast, there being then no cold-blast furnaces in operation in Scotland.

During the greater part of the currency of the patent, which lasted from October, 1828, to October, 1842, all the iron-masters in Scotland, and also those in England, who adopted the hot-blast, took out licences from the patentee, paying 1*s*, per ton, of iron smelted by them for the use of the invention. Latterly, however, the patent has been

challenged, both in England and Scotland, and on various grounds. It was stated by the counsel of Mr. Neilson, at this trial, that he had as yet succeeded in establishing his patent, having triumphed in every instance, and obtained damages from the parties working the hot-blast without his license, and who were thereby declared to have wrongfully used his invention, or invaded his patent. In these actions, as in the present, against the Messrs. Baird, of Gartsherrie, the defences resolved into various allegation. It was argued at this trial, that the patent was void, as being only for a principle; or, in other words, it stated, in effect, that hot air was better for smelting iron than cold air, without fulfilling the conditions of the law, by clearly specifying the practical mode in which this was to be accomplished; that, in fact, the patent merely embodied a principle, without clothing that principle with any practical effect, in order to render the patent valid. Further, assuming that the specification did profess to set forth a practical mode of executing the invention, still the patent was alleged to be void, because this mode, if followed, would lead to a false, or impracticable, result. Then it was alleged that Mr. Neilson was not the original inventor, seeing that the hot-blast had been practiced at other places, and that it was publicly known previous to the date of the patent. This did not imply, and the Lord Advocate, as leading counsel for the Messrs. Baird, disclaimed the idea, that Mr. Neilson had borrowed the discovery from another, but, simply, that the invention might be original as regarded the merit of Mr. Neilson, but still not the subject of a patent, if it turned out that it had been previously known, and publicly used, or disclosed by others, though such prior discovery was totally unknown to Mr. Neilson. The validity was also challenged, in respect that the directions in the specification would not, as the law requires, enable workmen of ordinary skill in such matters, to construct an apparatus useful for the purposes set forth in the patent.

The Dean of the Faculty of Advocates, (Patrick Robertson, Esq.,) detailed the whole circumstances of the case, and the various proceedings in the Court of Session, and House of Lords. He contended for the validity of the pursurer's patent—he undertook to prove that the defenders, by themselves and others, had invaded, or taken advantage of, it, whereby they had made great gains, or profits, and that they were justly liable to make reparation to the pursuers. He concluded a brilliant speech, which occupied nearly six hours, by calling upon the jury to find accordingly.

Evidence was then led in support of the issues for the pursuers, which occupied the court from Wednesday till the Monday following. This evidence consisted of practical and scientific men from all parts of the kingdom. At its conclusion,

The Lord Advocate of Scotland, (Duncan M'Neill, Esq.,) opened the case for the defenders, in a masterly speech of five hours, in which he analyzed the evidence of the pursuers, and undertook to prove that the pursuer, Mr. Neilson, was entitled to no credit for his invention, because the hot-blast, for which he obtained the patent, was in use, and well known, before the date of it; that the patent itself was void

in law, and that no damages were exigible by him, or by the pursuers, from the defenders. The evidence led by the defenders in support of the defence occupied the court from Tuesday till the afternoon of Friday.

A. Rutherfurd, Esq., (late Lord Advocate of Scotland,) then replied on the evidence, and on the whole case of the pursuers. His speech, which occupied four hours in the delivery, was clear, forcible, and lucid; he called upon the jury to protect his clients, whose legal and just rights had been invaded by the defenders amongst others, and to give exemplary damages under the issues.

The court then adjourned till the following day (Saturday).

The Lord President having resumed his seat on the bench, by half-past twelve o'clock, proceeded to charge the jury in a luminous, straightforward, and able manner. His Lordship's address occupied three hours and a half.

The Lord Advocate, on behalf of the defenders, having taken several exceptions to the views of the Lord President, the jury retired at half-past four, and, at six o'clock, returned, in effect, the following *Verdict*, unanimously finding in favor of the pursuers in all the issues: awarding 7000*l.* of damages, and 4867*l.* 16*s.* for profits—making in all, 11,867*l.* 16*s.* The 4867*l.* of profits being on 4392 tons manufactured within six weeks, the period specified in the present action.

Counsel for the Pursuers.—The Dean of Faculty (Patrick Robertson, Esq.,)Andrew Rutherfurd, Esq., (late Lord Advocate) the Solicitor-General, (Adam Aderson, Esq.,) and John Inglis, Esq., advocate. Edinburgh agents—G. and G. Dunlop, Esqs., W. S. Glasgow agents —Messrs. Bannatyne and Kirkwood.

Counsel for the Defenders.—The Lord Advocate, (Duncan M'Neill, Esq.,) Robert Whigham, Esq., Charles Neaves, Esq., P. Mure M'Credie, Esq. Edinburgh agents—Messrs. MacAndrew. Glasgow agents—Messrs. A. and A. Graham.

London Mining Journal.

Steam-Boiler Explosions. By J. A. Haswell.

Sir,—Within the last six months there have been three boiler explosions of a serious nature, in this county (Durham). One of these took place last Thursday (December 29th), at the Patent Rope Manufactory of Messrs. Rowland, Webster & Sons, Deptford, near this town, and deserves especially to be recorded in your *Magazine.*

The loss of life, and the destruction of property, in this case, may not place it amongst the very worst of accidents, but the peculiar nature of the explosion gives it a claim on your attention; and with your permission I will briefly state the facts connected with it.

The engine is a high-pressure one of 30 horse-power, and was worked by two cylindrical boilers, each 23 feet long, 5 feet diameter, pressed at 35 lbs. on the square inch. The boilers were in a good state of repair before the explosion; in fact, they might be considered as new. They were so connected together, as to have the benefit of

three safety-valves, to 3⅛ inches diameter, and one 4 inches diameter. The engine had been working all day at full work, and was to continue working until 10 o'clock at night; but at 6 o'clock the engineman was instructed to ease the engine, to enable the foreman to disconnect some of the machinery in the mill; when one of the boilers blew up with a tremendous crash, carrying away the roof of the apartment in which it was placed, and effecting other serious damage to the premises. Two of the workmen were much injured, and remain in a very precarious state; another person received a slight injury; and had it been a minute longer in occurring, there would have been not less than 20 men and women directly above the boiler, who would undoubtedly have lost their lives.

A few minutes after the explosion took place, the foreman, and engineer, (both practical men) and myself, examined the boiler, and found it torn across the middle, and longways towards the fire, on the bottom.

The boiler remained in its seat. A part was thrown up, and came in contact with a large T beam, 12 inches each way, and 1½ inch thick. This was broken into several pieces, which were thrown about in various directions. The force required to break the beam would be enormous, possibly sufficient to prevent the boiler from rising out of its place. The plates of the boiler were perfectly clean, but appeared to have been red-hot. The feed shut-off valve was quite shut, which would have prevented the water from going into the boiler, had the feed-pump been in a working state. There was no appearance of water about the building, except about a gallon in the other end of the boiler, which would accumulate from the stream rushing out of the boiler.

The opinion of several practical men, drawn from these facts, is that the explosion resulted from a deficiency of water in the boiler; and that the small portion left in it had been decomposed by the overheated plates, which had instantaneously generated *hydrogen* gas, possessing all the explosive force of gunpowder.

When we have before us such disastrous events as these, where so many lives, and such an amount of property, are depending on the attention of an individual, we ought to do all in our power towards hastening the time when our legislature will see the necessity of adopting a system of examination, which shall prevent engines and boilers being under the management of any but those "who are well trained, intelligent, and properly behaved, engineers—men who know something more about an engine, than to put on and off the steam."

Parliament has made some steps towards preventing inexperienced men taking charge of pit-engines; and surely if it be thought necessary to use caution in one case, we have an equal right to expect that those who may have charge of railway, steamboat, and factory engines, should be placed under the same restrictions, and not left to the care of men whose fitness for their task is left to be judged of by persons whose first consideration is the payment of the least amount of wages.

Pract. Mech. & Eng. Magazine.

On the Electricity evolved by the Friction of Water and Steam against other bodies. By MICHAEL FARADAY, ESQ.

The object of the experiments related in this paper, is to trace the source of the electricity which accompanies the issue of steam of high pressure, from the vessels in which it is contained. By means of a suitable apparatus, which the author describes and delineates, he found that electricity is never excited by the passage of pure steam, and is manifested only when water is at the same time present; and hence he concludes that it is altogether the effect of the friction of globules of water against the sides of the opening, or against the substances opposed to its passage, as the water is rapidly moved onwards by the current of steam. Accordingly, it was found to be increased in quantity, by increasing the pressure and impelling force of the steam. The immediate effect of this friction was, in all cases, to render the steam or water positive, and the solids, of whatever nature they might be, negative. In certain circumstances, however, as when a wire is placed in the current of steam at some distance from the orifice whence it has issued, the solid exhibits the positive electricity already acquired by the steam, and of which it is then merely the recipient and the conductor. In like manner, the results may be greatly modified by the shape, the nature, and the temperature of the passages through which the steam is forced. Heat, by preventing the condensation of the steam into water, likewise prevents the evolution of electricity, which again speedily appears by cooling the passages so as to restore the water which is necessary for the production of that effect. The phenomenon of the evolution of electricity in these circumstances, is dependent also on the quality of the fluid in motion, more especially in relation to its conducting power. Water will not excite electricity unless it be pure; the addition to it of any soluble salt or acid, even in minute quantity, is sufficient to destroy this property. The addition of oil of turpentine, on the other hand, occasions the devolopment of electricity of an opposite kind to that which is excited by water; and this the author explains by the particles, or minute globules, of the water having each received a coating of oil, in the form of a thin film, so that the friction takes place only between that external film and the solids, along the surface of which the globules are carried. A similar, but a more permanent, effect is produced by the presence of olive oil, which is not, like our turpentine, subject to rapid dissipation. Similar results were obtained when a stream of compressed air was substituted for steam in these experiments. When moisture was present, the solid exhibited negative, and the stream of air positive electricity; but when the air was perfectly dry, no electricity of any kind was apparent. The author concludes with an account of some experiments in which dry powders of various kinds were placed in the current of air; the results differed according to the nature of the substances employed, and other circumstances.

Lond. Athenæum.

Notice of some New Methods of Gilding and Silvering by Immersion.

By M. A. Levol.

At the present time, when great attention is being directed to the processes of gilding by the moist method, it seemed to me not without interest to publish an account of some new methods for gilding, or of silvering, by immersion, more especially on account of the facility of their execution.

Gilding on Silver.—Silver is very easily gilt by means of the neutral protochloride of gold, to which an aqueous solution of sulphocyanide of potassium has been added until the disappearance of the precipitate which at first formed. The liquor thus obtained should possess a slightly acid reaction, and if it has lost it, by too considerable an addition of sulphocyanide, it should be again restored by a few drops of hydrochloric acid. In order to gild, the well-cleansed silver is immersed in this liquor, nearly boiling, and moderately concentrated, in which state it is kept, adding from time to time, hot water to replace that which evaporates. In this manner the inconveniences which would result from too great an accumulation of the hydrochloric acid, the presence of which is nevertheless useful in preventing the formation of an auriferous precipitate, which would otherwise take place at the high temperature employed, were the alkali predominant, are obviated.

Gilding and Silvering on Copper, Brass, and Bronze.—A solution of cyanide of gold, and that of cyanide of silver in cyanide of potassium, has been recommended for gilding and silvering under the influence of electric forces. I have found that the same solutions, when at a temperature near their boiling point, may also be employed for gilding and silvering by immersion. Their preparation would be somewhat expensive were it necessary to obtain them chemically pure: but this would not offer the least advantage, and the operation may be simplified and rendered much less expensive by treating either the chloride of gold, or the nitrate of silver (both should be neutral) with an excess of cyanide of potassium, so as to obtain the soluble double cyanides.*

Silver cannot be gilt by this process, but it will be seen above that the sulphocyanide of gold, and of potassium, gilds this metal extremely well.

The solution of cyanide of copper in cyanide of potassium does not copper silver even in contact with zinc; but it coppers this last metal perfectly, and in a very solid manner.

I may observe, in conclusion, that these processes, so advantageous from their always succeeding, and requiring but a few minutes for every preparation, unfortunately do not allow but of the application

* As the cyanide of potassium is employed in a state of aqueous solution, and is very dear in the solid state, it is most advantageous to employ the mother-ley from the residue resulting from the calcination in a closed vessel of previously dried ferrocyanide of potassium. Its price then does not exceed a third of the commercial value of the double cyanide, and it might even be obtained at a still less price by the process indicated by Professor Liebig.

of a very thin layer of the precipitated metal. This inconvenience is common to all the processes by immersion.—*Journ. de Pharm. et de Chim.*, No. 3, March, 1842. Chem. Gazette.

Purification of Hydrochloric Acid of Commerce. By M. LAMBERT.

This process occasions little expense, and requires but little time, so that those manufacturers who may employ it, will be able to send into the market hydrochloric acid chemically pure, and costing scarcely a few farthings more a pound than the ordinary acid. When the acid to be purified contains sulphurous acid, which is the most usual case, I add a little binoxide of manganese, the oxygen of which converts the sulphurous into sulphuric acid. As, however, it is almost impossible to avoid, in so doing, the formation of a little chlorine, I add a small quantity of protochloride of iron, or even iron filings, which absorbs the free chlorine.*

When the acid contains no sulphurous acid, I convey a known quantity into a tubulated retort, adapt a tube in form of an S to the tubulure, and to the mouth a Woulf's apparatus, the jars of which contain distilled water, and are surrounded by cold water.†

The apparatus thus arranged, I introduce, by means of the tube S, a quantity of sulphuric acid of spec. grav. 1.834, twice that of the hydrochloric acid. For this purpose, I employ a funnel, drawn out, which is fixed in a firm manner above the tube, and in which rests an inverted flask containing sulphuric acid, which allows of the operation going on alone. The sulphuric acid combines with the water and liberates the gas, which dissolves in the water of the jars. It is important to employ concentrated hydrochloric acid (spec. grav. 1.178;) without this precaution, the gaseous acid would not be evolved immediately, and it would be less easy to obtain the whole. When the whole of the sulphuric acid has been added, the liquid is heated gradually to boiling; it then contains no more hydrochloric acid. Thus obtained, the hydrochloric acid is chemically pure;‡ and in this operation, the expenses are reduced to the concentration of the acid, which, brought from 1.628 to 1.834, may serve again for the same purpose, and even for the less delicate operations in the arts, and of the laboratory. It might also be used in many cases just as it is, *i. e.* at 1.628; and lastly, a manufacturer of chemicals who would purify hydrochloric acid by this means, would not have to employ heat, in order to obtain the last portions of the gaseous acid, as the weak sulphuric acid, containing the hydrochloric acid, may be employed in the preparation of this latter.—*Journ. de Pharm.*, March.

Chem. Gazette.

* When iron filings are employed, they must contain no copper, which would react on the sulphuric acid, and cause it to pass again into the state of sulphurous acid.

† I bring no water into the first jar, because at the end of the operation a small quantity of acid water passes over, and even of pure water, if the operation is carried too far.

‡ If the acid to be purified, contain arsenic, only the first portions are pure, and even then it is necessary that it should be concentrated at least to 1.178, to avoid the disengagement of any heat on the addition of sulphuric acid. This result is owing to the extreme volatility of the chloride of arsenic.

Galvanized Iron.

About five years since a patent was taken out in this country, by M. Sorel, for the purpose of galvanizing iron, by a process of coating it with zinc, in a similar manner to tinning, but for some cause, we believe a dispute among certain capitalists, this patent has been allowed to remain in abeyance, during which period, it has been in considerable use in France, and is, at the present time, we understand, extensively employed by the French government. It is now taken up in this country by some spirited individuals, who have established large works in London for zincing iron to any extent. The process may be applied to both cast and wrought iron in any form.

"The effect of zinc in protecting iron from oxidation," says Professor Graham, "has been known to chemists for some time. When these two metals are in contact, an electrical, or galvanic, relation is established between them, by which the iron ceases to be susceptible of corrosion by dilute acids, saline solution, or atmospheric humidity. It was found in experiments lately conducted at Dublin and Liverpool, that small pieces of zinc attached to each link of a chain-cable, were adequate to defend it from corrosion in sea water. The protection was observed to be complete, even in the upper portion of the iron chains by which buoys are moored, (and which, from being alternately exposed to sea water and air, is particularly liable to oxidation,) so long as the zinc remained in contact with the iron links. The protecting influence of the zinc could not be more certainly secured than in the articles prepared by the patent process, the iron surface being uniformly coated over by that metal. In trials to which I have had an opportunity of subjecting them, the iron escaped untouched in acid liquids, so long as a particle of the zinc covering remained undissolved. The same protection is afforded to iron in the open atmosphere by zinc, with a loss of its own substance, which is inappreciably minute. The zinc covering has the advantage over tinning, that, although it may be worn off, and the iron below it partially exposed, the iron is still secured from oxidation by the galvanic action, while the smallest quantity of zinc remains upon it; whereas tin, in common tin plate, affords no protection of this kind, and not being absolutely impermeable to air and moisture, the iron under it soon begins to rust in a damp atmosphere. The simplicity and perfect efficacy of the means employed to defend iron from the wasting influence of air and humidity in this process of *zinc tinning*, certainly entitle it to be ranked as one of the most valuable economical discoveries of the age."

Civ. Eng. and Arch. Jour.